

Project Manual

100% Construction Documents

Alger School Renovations
Grand Rapids Public Schools
Grand Rapids, Michigan

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PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes administrative and procedural requirements for unit prices.

1.2 DEFINITIONS

- A. Unit price is a price per unit of measurement for materials, equipment, or services, or a portion of the Work, added to or deducted from the Contract Sum by appropriate modification, if the scope of Work or estimated quantities of Work required by the Contract Documents are increased or decreased.

1.3 PROCEDURES

- A. Unit prices include all necessary material, plus cost for delivery, installation, insurance, overhead, and profit.
- B. Measurement and Payment: See individual Specification Sections for work that requires establishment of unit prices. Methods of measurement and payment for unit prices are specified in those Sections.
- C. Owner reserves the right to reject Contractor's measurement of work-in-place that involves use of established unit prices and to have this work measured, at Owner's expense, by an independent surveyor acceptable to Contractor.
- D. List of Unit Prices: A schedule of unit prices is included in Part 3. Specification Sections referenced in the Part 3 "Schedule of Unit Prices" Article contain requirements for materials described under each unit price.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF UNIT PRICES

- A. Unit Price No. 1: Cutting and patching of concrete slabs-on-grade.
 - 1. Description: Cutting of new or existing concrete slabs-on-grade up to 6 inches thick, removal and excavation as required, and subsequent backfill, compaction, and patching of concrete, not otherwise indicated in the Contract Documents.
 - 2. Unit of Measurement: square feet of concrete removed.
- B. Unit Price No. 2: Selective ceiling salvage and reinstallation
 - 1. Description: Removal and reinstallation of ACP ceilings for above ceiling mechanical work in accordance with Section 09 5113 - ACOUSTICAL PANEL CEILINGS
 - 2. Unit of Measurement: square feet of ceiling

- C. Unit Price No. 3: Interior painting
1. Description: Additional painting Section 09 9124 - INTERIOR PAINTING (MPI STANDARDS)
 2. Unit of Measurement: square feet of surface

END OF SECTION 01 2200

SECTION 01 4533 - QUALITY REQUIREMENTS AND STATEMENT OF SPECIAL INSPECTIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspection services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
 - 1. Specific quality-assurance and quality-control requirements for individual work results are specified in their respective Specification Sections. Requirements in individual Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and quality-control procedures that facilitate compliance with the Contract Document requirements.
 - 3. Requirements for Contractor to provide quality-assurance and quality-control services required by Architect, Owner, Commissioning Authority, Construction Manager, or authorities having jurisdiction are not limited by provisions of this Section.
- C. Special testing and special inspection services are required to comply with Chapter 17 of the 2021 Michigan Building Code.
 - 1. Specified special testing and inspections are in addition to conventional testing and inspection services required to verify compliance with Contract Documents.
 - 2. Statement of Special Inspections located at the end of this Section.

1.2 DEFINITIONS

- A. Experienced: When used with an entity or individual, "experienced," unless otherwise further described, means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.
- B. Field Quality-Control Tests and Inspections: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- C. Frequency of Test or Inspection:
 - 1. Continuous: The full-time observation of work requiring special inspection by an approved special inspector who is present in the area where work is being performed.
 - 2. Periodic: The part-time or intermittent observation of work requiring special inspection by an approved special inspector who is present where work is being done.

- D. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, subcontractor, or sub-subcontractor, to perform a particular construction operation, including installation, erection, application, assembly, and similar operations.
 - 1. Use of trade-specific terminology in referring to a Work result does not require that certain construction activities specified apply exclusively to specific trade(s).
- E. Mockups: Physical assemblies of portions of the Work constructed to establish the standard by which the Work will be judged. Mockups are not Samples.
 - 1. Mockups are used for one or more of the following:
 - a. Verify selections made under Sample submittals.
 - b. Demonstrate aesthetic effects.
 - c. Demonstrate the qualities of products and workmanship.
 - d. Demonstrate successful installation of interfaces between components and systems.
 - e. Perform preconstruction testing to determine system performance.
 - 2. Product Mockups: Mockups that may include multiple products, materials, or systems specified in a single Section.
 - 3. In-Place Mockups: Mockups constructed on-site in their actual final location as part of permanent construction.
- F. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria. Unless otherwise indicated, copies of reports of tests or inspections performed for other than the Project do not meet this definition.
- G. Product Tests: Tests and inspections that are performed by a nationally recognized testing laboratory (NRTL) in accordance with 29 CFR 1910.7, by a testing agency accredited in accordance with NIST's National Voluntary Laboratory Accreditation Program (NVLAP), or by a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.
- H. Source Quality-Control Tests and Inspections: Tests and inspections that are performed at the source (e.g., plant, mill, factory, or shop).
- I. Special Inspector: A properly qualified individual or firm performing special inspections.
- J. Special Testing and Special Inspection: Items required by the 2021 Michigan Building Code (MBC) based on the 2021 International Building Code (IBC) with amendments and additions.
- K. Testing Agency: An entity engaged to perform specific tests, inspections, or both. The term "testing laboratory" has the same meaning as the term "testing agency."
- L. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work, to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.

- M. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work, to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Contractor's quality-control services do not include contract administration activities performed by Architect or Construction Manager.

1.3 DELEGATED DESIGN SERVICES

- A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
 - 1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.
- B. Delegated Design Services Statement: Submit a statement signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional, indicating that the products and systems are in compliance with performance and design criteria indicated. Include list of codes, loads, and other factors used in performing these services.

1.4 CONFLICTING REQUIREMENTS

- A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements is specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, inform the Architect regarding the conflict and obtain clarification prior to proceeding with the Work. Refer conflicting requirements that are different, but apparently equal, to Architect for clarification before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified is the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Architect for a decision before proceeding.

1.5 ACTION SUBMITTALS

- A. Mockup Shop Drawings:
 - 1. Include plans, sections, elevations, and details, indicating materials and size of mockup construction.
 - 2. Indicate manufacturer and model number of individual components.
 - 3. Provide axonometric drawings for conditions difficult to illustrate in two dimensions.

1.6 INFORMATIONAL SUBMITTALS

- A. Contractor's Quality-Control Plan: For quality-assurance and quality-control activities and responsibilities.
- B. Qualification Data: For Contractor's quality-control personnel.
- C. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility submitted to authorities having jurisdiction before starting work on the following systems:
 - 1. Seismic-force-resisting system, designated seismic system, or component listed in the Statement of Special Inspections.
 - 2. Primary wind-force-resisting system or a wind-resisting component listed in the Statement of Special Inspections.
- D. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.
- E. Schedule of Tests and Inspections: Prepare in tabular form and include the following:
 - 1. Specification Section number and title.
 - 2. Entity responsible for performing tests and inspections.
 - 3. Description of test and inspection.
 - 4. Identification of applicable standards.
 - 5. Identification of test and inspection methods.
 - 6. Number of tests and inspections required.
 - 7. Time schedule or time span for tests and inspections.
 - 8. Requirements for obtaining samples.
 - 9. Unique characteristics of each quality-control service.
- F. Reports: Prepare and submit certified written reports and documents as specified.
- G. Permits, Licenses, and Certificates: For Owner's record, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents established for compliance with standards and regulations bearing on performance of the Work.

1.7 CONTRACTOR'S QUALITY-CONTROL PLAN

- A. Quality-Control Plan, General: Submit quality-control plan within 10 days of Notice to Proceed, and not less than five days prior to preconstruction conference. Submit in format acceptable to Architect. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-assurance and quality-control responsibilities and to coordinate Owner's quality-assurance and quality-control activities. Coordinate with Contractor's Construction Schedule.

- B. Quality-Control Personnel Qualifications: Engage qualified personnel trained and experienced in managing and executing quality-assurance and quality-control procedures similar in nature and extent to those required for Project.
 - 1. Project quality-control manager may also serve as Project superintendent.
- C. Submittal Procedure: Describe procedures for ensuring compliance with requirements through review and management of submittal process. Indicate qualifications of personnel responsible for submittal review.
- D. Testing and Inspection: In quality-control plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:
 - 1. Contractor-performed tests and inspections, including subcontractor-performed tests and inspections. Include required tests and inspections and Contractor-elected tests and inspections. Distinguish source quality-control tests and inspections from field quality-control tests and inspections.
 - 2. Special inspections required by authorities having jurisdiction and indicated on the Statement of Special Inspections.
 - 3. Owner-performed tests and inspections indicated in the Contract Documents, including tests and inspections indicated to be performed by Commissioning Authority.
- E. Continuous Inspection of Workmanship: Describe process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and inspection specified. Indicate types of corrective actions to be required to bring the Work into compliance with standards of workmanship established by Contract requirements and approved mockups.
- F. Monitoring and Documentation: Maintain testing and inspection reports, including log of approved and rejected results. Include Work Architect has indicated as nonconforming or defective. Indicate corrective actions taken to bring nonconforming Work into compliance with requirements. Comply with requirements of authorities having jurisdiction.

1.8 REPORTS AND DOCUMENTS

- A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:
 - 1. Date of issue.
 - 2. Project title and number.
 - 3. Name, address, telephone number, and email address of testing agency.
 - 4. Dates and locations of samples and tests or inspections.
 - 5. Names of individuals making tests and inspections.
 - 6. Description of the Work and test and inspection method.
 - 7. Identification of product and Specification Section.
 - 8. Complete test or inspection data.
 - 9. Test and inspection results and an interpretation of test results.
 - 10. Record of temperature and weather conditions at time of sample-taking and testing and inspection.

11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
 12. Name and signature of laboratory inspector.
 13. Recommendations on retesting and reinspecting.
- B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:
1. Name, address, telephone number, and email address of technical representative making report.
 2. Statement on condition of substrates and their acceptability for installation of product.
 3. Statement that products at Project site comply with requirements.
 4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
 5. Results of operational and other tests and a statement of whether observed performance complies with requirements.
 6. Statement of whether conditions, products, and installation will affect warranty.
 7. Other required items indicated in individual Specification Sections.
- C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:
1. Name, address, telephone number, and email address of factory-authorized service representative making report.
 2. Statement that equipment complies with requirements.
 3. Results of operational and other tests and a statement of whether observed performance complies with requirements.
 4. Statement of whether conditions, products, and installation will affect warranty.
 5. Other required items indicated in individual Specification Sections.

1.9 QUALITY ASSURANCE

- A. Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units. As applicable, procure products from manufacturers able to meet qualification requirements, warranty requirements, and technical or factory-authorized service representative requirements.
- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

- D. **Installer Qualifications:** A firm or individual experienced in installing, erecting, applying, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. **Professional Engineer Qualifications:** A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or product that is similar in material, design, and extent to those indicated for this Project.
- F. **Specialists:** Certain Specification Sections require that specific construction activities be performed by entities who are recognized experts in those operations. Specialists will satisfy qualification requirements indicated and engage in the activities indicated.
 - 1. Requirements of authorities having jurisdiction supersede requirements for specialists.
- G. **Testing and Inspecting Agency Qualifications:** An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspection indicated, as documented in accordance with ASTM E329, and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.
- H. **Manufacturer's Technical Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- I. **Factory-Authorized Service Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to inspect, demonstrate, repair, and perform service on installations of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- J. **Preconstruction Testing:** Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:
 - 1. **Contractor's Responsibilities:**
 - a. Provide test specimens representative of proposed products and construction.
 - b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
 - c. Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
 - d. Build site-assembled test assemblies and mockups, using installers who will perform same tasks for Project.
 - e. When testing is complete, remove test specimens and test assemblies, and mockups; do not reuse products on Project.

2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Architect and Commissioning Authority, through Construction Manager, with copy to Contractor. Interpret tests and inspections, and state in each report whether tested and inspected Work complies with or deviates from the Contract Documents.
- K. Mockups: Before installing portions of the Work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed Work:
1. Build mockups of size indicated.
 2. Build mockups in location indicated or, if not indicated, as directed by Architect or Construction Manager.
 3. Notify Architect and Construction Manager seven days in advance of dates and times when mockups will be constructed.
 4. Employ supervisory personnel who will oversee mockup construction. Employ workers who will be employed to perform same tasks during the construction at Project.
 5. Demonstrate the proposed range of aesthetic effects and workmanship.
 6. Obtain Architect's and Construction Manager's approval of mockups before starting corresponding Work, fabrication, or construction.
 - a. Allow seven days for initial review and each re-review of each mockup.
 7. Promptly correct unsatisfactory conditions noted by Architect's preliminary review, to the satisfaction of the Architect, before completion of final mockup.
 8. Approval of mockups by the Architect does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 9. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 10. Demolish and remove mockups when directed unless otherwise indicated.

1.10 QUALITY CONTROL

- A. Owner Responsibilities: Where quality-control services are indicated as Owner's responsibility, Owner will engage a qualified testing agency to perform these services.
1. Owner will furnish Contractor with names, addresses, and telephone numbers of testing agencies engaged and a description of types of testing and inspection they are engaged to perform.
 2. Costs for retesting and reinspecting construction that replaces or is necessitated by Work that failed to comply with the Contract Documents will be charged to Contractor.
- B. Contractor Responsibilities: Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Perform additional quality-control activities, whether specified or not, to verify and document that the Work complies with requirements.
1. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.

2. Engage a qualified testing agency to perform quality-control services.
 - a. Contractor will not employ same entity engaged by Owner, unless agreed to in writing by Owner.
 3. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspection will be performed.
 4. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
 5. Testing and inspection requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
 6. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.
- C. Retesting/Reinspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.
- D. Testing Agency Responsibilities: Cooperate with Architect, Commissioning Authority, Construction Manager, and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
1. Notify Architect, Commissioning Authority, Construction Manager, and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
 2. Determine the locations from which test samples will be taken and in which in-situ tests are conducted.
 3. Conduct and interpret tests and inspections, and state in each report whether tested and inspected Work complies with or deviates from requirements.
 4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
 5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
 6. Do not perform duties of Contractor.
- E. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 01 3300 "Submittal Procedures."
- F. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in preinstallation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.

- G. Contractor's Associated Requirements and Services: Cooperate with agencies and representatives performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
1. Access to the Work.
 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 3. Adequate quantities of representative samples of materials that require testing and inspection. Assist agency in obtaining samples.
 4. Facilities for storage and field curing of test samples.
 5. Delivery of samples to testing agencies.
 6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
 7. Security and protection for samples and for testing and inspection equipment at Project site.
- H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspection.
1. Schedule times for tests, inspections, obtaining samples, and similar activities.
- I. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a component of Contractor's quality-control plan. Coordinate and submit concurrently with Contractor's Construction Schedule. Update and submit with each Application for Payment.
1. Schedule Contents: Include tests, inspections, and quality-control services, including Contractor- and Owner-retained services, commissioning activities, and other Project-required services paid for by other entities.
 2. Distribution: Distribute schedule to Owner, Architect, Commissioning Authority, Construction Manager, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

1.11 SPECIAL TESTS AND INSPECTIONS

- A. Special Tests and Inspections: Owner will engage a qualified testing agency to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of Owner, as indicated in the Statement of Special Inspections attached to this Section, and as follows:
1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviewing the completeness and adequacy of those procedures to perform the Work.
 2. Notifying Architect, Commissioning Authority, Construction Manager, and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
 3. Submitting a certified written report of each test, inspection, and similar quality-control service to Architect and Commissioning Authority, through Construction Manager, with copy to Contractor and to authorities having jurisdiction.
 4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.

5. Interpreting tests and inspections, and stating in each report whether tested and inspected Work complies with or deviates from the Contract Documents.
6. Retesting and reinspecting corrected Work.

PART 2 - PRODUCTS (Not Used)**PART 3 - EXECUTION****3.1 TEST AND INSPECTION LOG**

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
 1. Date test or inspection was conducted.
 2. Description of the Work tested or inspected.
 3. Date test or inspection results were transmitted to Architect.
 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Architect's, Commissioning Authority's, and Construction Manager's and authorities' having jurisdiction reference during normal working hours.
 1. Submit log at Project closeout as part of Project Record Documents.

3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspection, sample-taking, and similar services, repair damaged construction and restore substrates and finishes.
 1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.
- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

PART 4 - STATEMENT OF SPECIAL INSPECTIONS (SSI)

Components not requiring special inspection are either not included in the construction or exempted based on the Michigan Building Code Section 1705.

MBC 1705.1			SPECIAL CASES AS DETERMINED BY THE BUILDING OFFICIAL
REQUIRED	CONTINUOUS	PERIODIC	CODE-REQUIRED SPECIAL INSPECTIONS & TESTING PER MICHIGAN BUILDING CODE, 2021 (MBC)
			Construction materials and systems that are alternatives to materials and systems prescribed by this code.
			Unusual design applications of materials described in this code.
			Materials and systems required to be installed in accordance with additional manufacturer's instructions that prescribe requirements not contained in this code or in standards referenced by this code.
MBC 1705.2			STEEL CONSTRUCTION
☐	P	O	1705.2.1 Structural Steel Special inspection and nondestructive testing of structural steel elements in buildings, structures and portions thereof shall be in accordance with the quality assurance inspection requirements of AISC 360-16, Chapter N. P = Perform for each welded joint or members, for each bolted connection, and for each steel element. O = Observe items on a random basis. Operations need not be delayed pending these inspections.
☐			1705.2.2 Cold-Formed Steel Deck Special inspections and qualification of welding special inspectors in accordance with the quality assurance inspection requirements of SDI QA/QC.
☐		X	1705.2.3 Open-Web Steel Joists and Joist Girders (SJI 100 or SJI 200 as applicable) Installation of open-web steel joists and joist girders. 1. Welded or bolted End Connections 2. Horizontal or Diagonal Bridge
☐			1705.2.4 Cold-Formed Steel Trusses Spanning 60 Feet or Greater Special inspection of the installation of temporary and permanent restraint and bracing are in accordance with the approved truss submittal package.

MBC 1705.3			CONCRETE CONSTRUCTION (ACI 318)
☒		X	Inspect reinforcement, including prestressing tendons, and verify placement.
☐			Reinforcing bar welding (AWS D1.4):
☐			Verify weldability of reinforcing bars other than ASTM A706.
☐			Inspect single-pass fillet welds, maximum 5/16".
☐			Inspect all other welds.
☒		X	Inspect anchors cast in concrete.
☒		X	Inspect anchors post-installed in hardened concrete members.
☐			Adhesive anchors installed in horizontally or upwardly inclined orientations to resist sustained tension loads.
☒		X	Mechanical anchors and adhesive anchors not defined in row above.
☒		X	Verify use of required design mix.
☒	X		Prior to concrete placement, fabricate specimens for strength tests, perform slump and air content tests, and determine the temperature of the concrete.
☐			For precast concrete diaphragm connections or reinforcement at joints classified as moderate or high deformability elements (MDE or HDE) in structures assigned to Seismic Design Category C, D, E or F, inspect such connections and reinforcement in the field for: Installation of the embedded parts. Completion of the continuity of reinforcement across joints. Completion of connections in the field
☐			Inspect installation tolerances or precast concrete diaphragm connections for compliance with ACI 550.5.
☒		X	Verify in-situ concrete strength, prior to stressing of tendons in post-tensioned concrete and prior to removal of shores and forms from beams and structural slabs.
☒		X	Inspect formwork for shape, location and dimensions of the concrete members being formed.

MBC 1705.4			MASONRY CONSTRUCTION (TMS 402/602)
☐			LEVEL A QUALITY ASSURANCE: The minimum quality assurance program for masonry in Risk Category I, II, or III structures and designed in accordance with Part 4 or Appendix A shall comply with Table 3.1.1.
☐			LEVEL B QUALITY ASSURANCE: The minimum quality assurance program for masonry in Risk Category I, II, or III structures and designed in accordance with Chapters other than those in Part A or Appendix A shall comply with Table 3.1.2.
☐			LEVEL B QUALITY ASSURANCE: The minimum quality assurance program for masonry in Risk Category IV structures and designed in accordance with Chapter 12 or 13 shall comply with Table 3.1.2.
☐			LEVEL C QUALITY ASSURANCE: The minimum quality assurance program for masonry in Risk Category IV structures and designed in accordance with Chapters other than those in Part 4 or Appendix A with Table 3.1.3.
☐			1705.4.1 Glass Unit Masonry and Masonry Veneer in Risk Category IV Special inspection and tests for glass unit masonry or masonry veneer where they are part of a structure classified as Risk Category IV (TMS 602 Level 2).
☐			1705.4.2 Vertical Masonry Foundation Elements Special inspections and tests of vertical masonry foundation elements shall be performed in accordance with Section 1705.4 of MBC.
MBC 1705.5			WOOD CONSTRUCTION
☐			1705.5.1 High-Load Diaphragms Inspect the wood structural panel sheathing grade and thickness and verify the nominal size of framing members at adjoining panel edges, the nail or staple diameter and length, the number of fastener lines and that the spacing between fasteners in each line and at edge margins agrees with the approved construction documents.
☐			1705.5.2 Metal-Plate-Connected Wood Trusses Spanning 60 Feet or Greater Verify temporary and permanent restraint/bracing are installed in accordance with the truss submittal package.
☐			1705.5.3 Mass Timber Construction 1. Inspection of anchorage and connections of mass timber construction to timber deep foundation systems. 2. Inspect erection of mass timber construction. 3. Inspection of connections where installation methods are required to meet design loads. a. Verify use of proper installation equipment b. Verify use of pre-drilled holes where required.
☐			c. Inspect screws, including diameter, length, head type, spacing, installation angle and depth.

☐			4. Adhesive anchors not defined in Item #3 above. 5. Bolted Connections. 6. Concealed Connections.
MBC 1705.6		SOILS	
☐	X		1. Verify materials below shallow foundations are adequate to achieve the design bearing capacity.
☐	X		2. Verify excavations are extended to proper depth and have reached proper material.
☐		X	3. Perform classification and testing on compacted fill materials.
☐		X	4. During fill placement, verify use of proper materials and procedures in accordance with the provisions of the approved geotechnical report. Verify densities and lift thicknesses during placement and compaction of compacted fill.
☐		X	5. Prior to placement of compacted fill, inspect subgrade and verify that site has been prepared properly.
MBC 1705.7		DRIVEN DEEP FOUNDATIONS	
☐			1. Verify element materials, sizes and lengths comply with the requirements.
☐			2. Determine capacities of test elements and conduct additional load tests, as required.
☐			3. Inspect driving operations and maintain complete and accurate records for each element.
☐			4. Verify placement locations and plumbness, confirm type and size of hammer, record number of blows per foot of penetration, determine required penetrations to achieve design capacity, record tip and butt elevations and document any damage to foundation element.
☐			5. For steel elements, perform additional special inspections in accordance with Section 1705.2.
☐			6. For concrete elements and concrete-filled elements, perform tests and additional special inspections in accordance with Section 1705.3.
☐			7. For specialty elements, perform additional inspections as determined by the registered design professional in responsible charge.
MBC 1705.8		CAST-IN-PLACE DEEP FOUNDATIONS	
☐			1. Inspect drilling operations and maintain complete and accurate records for each element.
☐			2. Verify placement locations and plumbness, confirm element diameters, bell diameters (if applicable), lengths, embedment into bedrock (if applicable) and adequate end-bearing strata capacity. Record concrete or grout volumes.
☐			3. For concrete elements and concrete-filled elements, perform tests and additional special inspections in accordance with Section 1705.3.

MBC 1705.9			HELICAL PILE FOUNDATIONS
☐			Verify installation equipment used, pile dimensions, tip elevations, final depth, final installation torque comply with approved geotechnical report and construction documents.
MBC 1705.10			STRUCTURAL INTEGRITY OF DEEP FOUNDATIONS
☐			Engineering assessment of deep foundation element including tests for defects performed in accordance with ASTM D4945, ASTM D5882, ASTM D6760 or ASTM D7949 or other approved method.
MBC 1705.11			FABRICATED ITEMS
☐			Inspect fabrication of structural, load bearing, or lateral load-resisting members or assemblies (not required where fabricator has been approved to perform work without special inspections in accordance with MBC Section 1704.2.5.1)
MBC 1705.12			WIND RESISTANCE
			1705.12.1 Structural Wood
☐			1. Inspect field gluing of wood shear walls, wood diaphragms, drag struts, braces, and hold-downs of elements of the main windforce-resisting system including wood shear walls, wood diaphragms, drag struts, braces and hold-downs.
☐			2. Inspect nailing, bolting, anchoring, and other fastening of elements of the main windforce-resisting system including wood shear walls, wood diaphragms, drag struts, braces and hold-downs.
☐			1705.12.2 Cold-formed Steel Light-Frame Construction Inspect welding operations, screw attachment, bolting, anchoring, and other fastening of the main windforce-resisting system including shear walls, braces, diaphragms, collectors (drag struts), and hold-downs.
☐			1705.12.3 Wind-resisting Components 1. Inspect fastening of roof covering, roof deck, and roof framing connections. 2. Inspect exterior wall covering and wall connections to roof and floor diaphragms and framing.
MBC 1705.13			SEISMIC RESISTANCE
			1705.13.1 Structural Steel
☐			1. Seismic Force-Resisting System. Inspect in accordance with the quality assurance requirements of AISC 341.
☐			2. Structural Steel Elements. Inspect structural steel elements in the seismic-force resisting system including struts, collectors, chords and foundation elements in accordance with the quality assurance requirements of AISC 341.

			1705.13.2 Structural Wood
☐			1. Inspect field gluing of wood shear walls, wood diaphragms, drag struts, braces, and hold-downs of elements of the main windforce-resisting system including wood shear walls, wood diaphragms, drag struts, braces and hold-downs.
☐			2. Inspect nailing, bolting, anchoring, and other fastening of elements of the main windforce-resisting system including wood shear walls, wood diaphragms, drag struts, braces and hold-downs.
☐			1705.13.3 Cold-formed Steel Light-frame Construction Inspect welding operations, screw attachment, bolting, anchoring, and other fastening of the main windforce-resisting system including shear walls, braces, diaphragms, collectors (drag struts), and hold-downs.
☐			1705.13.4 Designated Seismic Systems 1. Examine designated seismic systems requiring seismic qualification in accordance with Section 13.2.2 of ASCE 7. 2. Verify that the label anchorage and mounting conform to the certificate of compliance.
☐			1705.13.5 Architectural Components 1. Inspect installation and fastening of exterior cladding, nonbearing walls and veneer. 2. Inspect anchorage of access floors.
			1705.13.6 Plumbing, mechanical and electrical components
☐			1. Anchorage of electrical equipment for emergency and standby power systems.
☐			2. Anchorage of other electrical equipment.
☐			3 and 4. Installation and anchorage of piping systems and ductwork designed to carry hazardous materials and their associated mechanical units.
☐			5. Installation and anchorage of vibration isolation systems.
☐			6. Installation of mechanical and electrical equipment, including duct work, piping systems and their structural supports, where automatic sprinkler systems are installed. a. Minimum clearances meet Section 13.2.3 of ASCE/SEI 7 b. Nominal clearance of 3-inches or more provided between automatic sprinkler system drops and sprigs and: structural members not used collectively or independently to support the sprinklers; equipment attached to the building structure; and other systems' piping.
☐			1705.13.7 Storage Racks Inspect steel storage racks and steel cantilevered racks that are 8-feet in height or greater.
☐			1705.13.8 Seismic Isolation System Inspect fabrication and installation of isolator units and energy dissipation devices.

☐			1705.13.9 Cold-formed Steel Special Bolted Moment Frames Inspect installation of cold-formed steel special bolted moment frames.
MBC 1705.14			TESTING FOR SEISMIC RESISTANCE
			1705.14.1 Structural Steel
☐			1. Seismic Force-Resisting System. Non-destructive testing in accordance with the quality assurance requirements of AISC 341.
☐			2. Structural Steel Elements. Non-destructive testing of structural steel elements in the seismic-force resisting system including struts, collectors, chords and foundation elements in accordance with the quality assurance requirements of AISC 341.
☐			1705.14.2 Nonstructural Components Verify analysis, testing, or experience data meets requirements on construction documents. Submit certificates of compliance document that requirements are met to the building official.
☐			1705.14.3 Designated Seismic Systems Verify analysis, testing, or experience data meets requirements on construction documents. Submit certificates of compliance document that requirements are met to the building official.
☐			1705.14.3 Seismic Isolation Systems Tested in accordance with Section 17.8 of ASCE 7.
MBC 1705.15			SPRAYED FIRE-RESISTANT MATERIALS
☐			1705.15.1 Physical and Visual Tests Inspect and test the following to verify compliance with the listing and fire-resistant rating: 1. Condition of substrates. 2. Thickness of application. 3. Density in pounds per cubic foot. 4. Bond strength adhesion/cohesion 5. Condition of finished application.
☐			1705.15.2 Structural Member Surface Conditions Inspect prepared surface before application of sprayed fire-resistant material.
☐			1705.15.3 Application Inspect application of sprayed fire-resistant material.
☐			1705.15.4 Thickness Test thickness of materials applied to floor, roof and wall assemblies and structural members. Verify they meet requirements of the approved fire-resistance design and minimum allowable thicknesses.
☐			1705.15.5. Density Test density of materials applied to floor, roof and wall assemblies and structural members. Verify they meet requirements of the approved fire-resistance design. Determine density in accordance with ASTM E605.

☐		1705.15.5. Bond Strength Test in-place samples in accordance with the field test specified in ASTM E736 for compliance with minimum requirements listed in MBC.
MBC 1705.16		MASTIC AND INTUMESCENT FIRE-RESISTANT COATINGS
☐		Inspect and test mastic and intumescent fire-resistant coatings applied to structural elements and decks in accordance with AWCI 12-B.
MBC 1705.17		EXTERIOR INSULATION AND FINISH SYSTEMS (EIFS)
☐		Inspect installation of EIFS system and water-resistive barrier coating where installed over a sheathing substrate.
MBC 1705.18		FIRE-RESISTANT PENETRATION AND JOINTS
☐		1705.18.1 Penetration Firestops Inspect penetration firestop systems that are tested and listed in accordance with Sections 714.4.1.2 and 714.5.1.2 in accordance with ASTM E2393.
☐		1705.18.2 Fire-resistant Joint Systems Inspect fire-resistant joint systems that are tested and listed in accordance with Sections 715.3.1 and 715.4 in accordance with ASTM E2393.
MBC 1705.19		TESTING FOR SMOKE CONTROL
☐		Test smoke control systems: 1. During erection of ductwork and prior to concealment for the purposes of leakage testing and recording of device location. 2. Prior to occupancy and after sufficient completion for the purposes of pressure difference testing, flow measurements and detection and control verification.
MBC 1705.20		SEALING OF MASS TIMBER
☐		Inspect sealants and adhesives where sealant or adhesive required by Section 703.7 is applied to mass timber building elements as designated in the construction documents.

END OF SECTION 01 4533

SECTION 01 5639 - TEMPORARY TREE AND PLANT PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section Includes: General protection and pruning of existing trees and plants that are affected by execution of the Work, whether temporary or permanent construction.
- B. Related Requirements:
 - 1. Section 31 1000 "Site Clearing" for removing existing trees and shrubs and for temporary erosion- and sedimentation-control measures

1.2 DEFINITIONS

- A. Caliper (DBH): Diameter breast height; diameter of a trunk as measured by a diameter tape at a height 54 inches above the ground line.
- B. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction.
- C. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings indicated to remain, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.
 - 1. Use sufficiently detailed photographs or video recordings.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

1.4 FIELD CONDITIONS

- A. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Moving or parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- B. Do not direct vehicle or equipment exhaust toward protection zones.
- C. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

- D. Take precautions to protect plants from airborne contaminants, such as paint or fireproofing overspray.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
 - 1. Type: Shredded hardwood.
 - 2. Color: Natural.
- B. Protection-Zone Fencing: Fencing fixed in position and meeting one of the following requirements: Previously used materials may be used when approved by Architect.
 - 1. Chain-Link Protection-Zone Fencing: Galvanized-steel fencing fabricated from minimum 2-inch opening, 0.148-inch- diameter wire chain-link fabric; with pipe posts, minimum 2-3/8-inch- OD line posts, and 2-7/8-inch- OD corner and pull posts; with 1-5/8-inch- OD top rails and 0.177-inch- diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
 - a. Height: 72 inches.
 - 2. Plywood Protection-Zone Fencing: Plywood framed with four 2-by-4-inch rails, with 4-by-4-inch preservative-treated wood posts spaced not more than 96 inches apart.
 - a. Height: 72 inches.
 - b. Plywood and Lumber: Comply with requirements in Section 06 1000 "Rough Carpentry."
 - 3. Wood Protection-Zone Fencing: Constructed of two 2-by-4-inch horizontal rails, with 4-by-4-inch preservative-treated wood posts spaced not more than 96 inches apart, and lower rail set halfway between top rail and ground.
 - a. Height: 72 inches.
 - b. Lumber: Comply with requirements in Section 06 1000 "Rough Carpentry."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Erosion and Sedimentation Control: Examine the site to verify that temporary erosion- and sedimentation-control measures are in place. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- B. Prepare written report, endorsed by arborist, listing conditions detrimental to tree and plant protection.

3.2 PREPARATION

- A. Locate and clearly identify trees, shrubs, and other vegetation to remain.

- B. Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Protect root systems from ponding, eroding, or excessive wetting caused by dewatering operations.

3.3 TREE PROTECTION

- A. Tree-Protection Zones: Mulch areas inside tree-protection zones and other areas indicated. Do not exceed indicated thickness of mulch.
 - 1. Apply 4-inch uniform thickness of organic mulch unless otherwise indicated. Do not place mulch within 6 inches of tree trunks.

3.4 PROTECTION ZONES

- A. Protection-Zone Fencing: Install protection-zone fencing along edges of protection zones before materials or equipment are brought on the site and construction operations begin in a manner that will prevent people from easily entering protected areas except by entrance gates. Construct fencing so as not to obstruct safe passage or visibility at vehicle intersections where fencing is located adjacent to pedestrian walkways or in close proximity to street intersections, drives, or other vehicular circulation.
 - 1. Chain-Link Fencing: Install to comply with ASTM F567 and with manufacturer's written instructions.
 - 2. Posts: Set or drive posts into ground one-third the total height of the fence without concrete footings. Where a post is located on existing paving or concrete to remain, provide appropriate means of post support acceptable to Architect.
 - 3. Access Gates: Install as required; adjust to operate smoothly, easily, and quietly; free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Maintain protection zones free of weeds and trash.
- C. Maintain hydration of plants to assure plant survival.
- D. Maintain protection-zone fencing in good condition as acceptable to Architect and remove when construction operations are complete and equipment has been removed from the site.
 - 1. Do not remove protection-zone fencing, even temporarily, to allow deliveries or equipment access through the protection zone.

3.5 EXCAVATION

- A. Trenching within Protection Zones: Where utility trenches are required within protection zones, excavate under or around tree roots by hand or with air spade, or tunnel under the roots by drilling, auger boring, or pipe jacking. Do not cut main lateral tree roots or taproots; cut only smaller roots that interfere with installation of utilities. Cut roots as required for root pruning. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots.

3.6 ROOT PRUNING

- A. Prune tree roots that are affected by temporary and permanent construction. Prune roots as follows:
 - 1. Cut roots manually by digging a trench and cutting exposed roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
 - 2. Cut Ends: Do not paint cut root ends.
 - 3. Temporarily support and protect roots from damage until they are permanently covered with soil.
 - 4. Cover exposed roots with burlap and water regularly.
 - 5. Backfill as soon as possible in accordance with requirements in Section 31 2000 "Earth Moving."
- B. Root Pruning at Edge of Protection Zone: Prune tree roots 12 inches outside of the protection zone by cleanly cutting all roots to the depth of the required excavation.

3.7 CROWN PRUNING

- A. Prune branches that are affected by temporary and permanent construction.
 - 1. Prune to remove only injured, broken, dying, or dead branches unless otherwise indicated. Do not prune for shape unless otherwise indicated.
 - 2. Do not remove or reduce living branches to compensate for root loss caused by damaging or cutting root system.
 - 3. Pruning Standards: Prune trees in accordance with ANSI A300 (Part 1).
- B. Unless otherwise directed by arborist and acceptable to Architect, do not cut tree leaders.
- C. Cut branches with sharp pruning instruments; do not break or chop.
- D. Do not paint or apply sealants to wounds.
- E. Provide subsequent maintenance pruning during Contract period as recommended by arborist.
- F. Chip removed branches and dispose of off-site.

3.8 REPAIR AND REPLACEMENT

- A. General: Repair or replace trees, shrubs, and other vegetation indicated to remain or to be relocated that are damaged by construction operations, in a manner approved by Architect.
 - 1. Submit details of proposed pruning and repairs.
 - 2. Perform repairs of damaged trunks, branches, and roots within 24 hours in accordance with arborist's written instructions.
 - 3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

- B. Trees: Remove and replace trees indicated to remain that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.
 - 1. Provide new trees of same species and a minimum of 2 inches in caliper size as those being replaced.

END OF SECTION 01 5639

SECTION 01 9113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. General requirements for coordinating and scheduling commissioning activities.
 - 2. Commissioning meetings.
 - 3. Commissioning reports.
 - 4. Use of commissioning process test equipment, instrumentation, and tools.
 - 5. Construction checklists, including, but not limited to, installation checks, startup, performance tests, and performance test demonstration.
 - 6. Commissioning tests and commissioning test demonstration.
 - 7. Adjusting, verifying, and documenting identified systems and assemblies.
- B. Related Requirements:
 - 1. Section 22 0800 "Commissioning of Plumbing" for technical commissioning requirements for plumbing.
 - 2. Section 23 0800 "Commissioning of HVAC" for technical commissioning requirements for HVAC.

1.2 DEFINITIONS

- A. Acceptance Criteria: Threshold of acceptable work quality or performance specified for a commissioning activity, including, but not limited to, construction checklists, performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.
- B. Basis-of-Design Document: A document prepared by Architect that records concepts, calculations, decisions, and product selections used to comply with Owner's Project Requirements and to suit applicable regulatory requirements, standards, and guidelines.
- C. Commissioning Authority: An entity engaged by Owner.
- D. Commissioning Plan: A document, prepared by Commissioning Authority, that outlines the organization, schedule, allocation of resources, and documentation of commissioning requirements.
- E. Commissioning: A quality-focused process for verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, and tested to comply with Owner's Project Requirements. The requirements specified here are limited to the construction phase commissioning activities.

- F. Construction-Phase Commissioning-Process Completion: The stage of completion and acceptance of commissioning process when resolution of deficient conditions and issues discovered during commissioning process and retesting until acceptable results are obtained has been accomplished. Owner will establish in writing the date construction-phase commissioning-process completion is achieved.
 - 1. Commissioning process is complete when the Work specified of this Section and related Sections has been completed and accepted, including, but not limited to, the following:
 - a. Completion of tests and acceptance of test results.
 - b. Resolution of issues, as verified by retests performed and documented with acceptance of retest results.
 - c. Completion and acceptance of submittals and reports.
- G. Owner's Project Requirements: A document that details the functional requirements of a project and the expectations of how it will be used and operated, including Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This document is prepared either by the Owner or for the Owner by the Architect or Commissioning Authority.
- H. Owner's Witness: Commissioning Authority, Owner's Project Manager, or Architect-designated witness authorized to authenticate test demonstration data and to sign completed test data forms.
- I. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.
- J. Test: Performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.
- K. Sampling Procedures and Tables for Inspection by Attributes: As defined in ASQ Z1.4.

1.3 COMPENSATION

- A. If Architect, Commissioning Authority, other Owner's witness, or Owner's staff perform additional services or incur additional expenses due to actions of Contractor listed below, compensate Owner for such additional services and expenses.
 - 1. Failure to meet acceptance criteria for test demonstrations.

1.4 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s):
 - 1. Commissioning Coordinator: A person or entity employed by Contractor to manage, schedule, and coordinate commissioning process.
 - 2. Project superintendent and other employees that Contractor may deem appropriate for a particular portion of the commissioning process.
 - 3. Subcontractors, installers, suppliers, and specialists that Contractor may deem appropriate for a particular portion of the commissioning process.

4. Appointed team members shall have the authority to act on behalf of the entity they represent.
- B. Members Appointed by Owner:
1. Commissioning Authority, plus consultants that Commissioning Authority may deem appropriate for a particular portion of the commissioning process.
 2. Owner representative(s), facility operations and maintenance personnel, plus other employees, separate contractors, and consultants that Owner may deem appropriate for a particular portion of the commissioning process.
 3. Architect, plus employees and consultants that Architect may deem appropriate for a particular portion of the commissioning process.

1.5 INFORMATIONAL SUBMITTALS

- A. Commissioning Plan Information:
1. List of Contractor-appointed commissioning team members to include specific personnel and subcontractors performing the various commissioning requirements.
 2. Schedule of commissioning activities, integrated with the Construction Schedule.
 3. Contractor personnel and subcontractors participating in each test.
 4. List of instrumentation required for each test to include identification of parties that will provide instrumentation for each test.
- B. Commissioning schedule.
- C. Commissioning Coordinator Letter of Authority:
1. Within 10 days after approval of Commissioning Coordinator qualifications, submit a letter of authority for Commissioning Coordinator, signed by a principal of Contractor's firm. Letter shall authorize Commissioning Coordinator to do the following:
 - a. Make inspections required for commissioning process.
 - b. Coordinate, schedule, and manage commissioning process of Contractor, subcontractors, and suppliers.
 - c. Obtain documentation required for commissioning process from Contractor, subcontractors, and suppliers.
 - d. Report issues, delayed resolution of issues, schedule conflicts, and lack of cooperation or expertise on the part of commissioning team members.
- D. Test Reports:
1. Pre-Startup Report: Prior to startup of equipment or a system, submit signed, completed construction checklists.
 2. Test Data Reports: At the end of each day in which tests are conducted, submit test data for tests performed.
 3. Commissioning Issue Reports: Daily, at the end of each day in which tests are conducted, submit commissioning issue reports for tests for which acceptable results were not achieved.
 4. Weekly Progress Report: Weekly, at the end of each week in which tests are conducted, submit a progress report.
 5. Data Trend Logs: Submit data trend logs at the end of the trend log period.

- E. Construction Checklists:
 - 1. Installation checks.
 - 2. Startup procedures, where required.

1.6 CLOSEOUT SUBMITTALS

- A. Commissioning Report:
 - 1. At Construction-Phase Commissioning Completion, include the following:
 - a. Pre-startup reports.
 - b. Approved test procedures.
 - c. Test data forms, completed and signed.
 - d. Progress reports.
 - e. Commissioning issue report log.
 - f. Commissioning issue reports showing resolution of issues.
 - g. Correspondence or other documents related to resolution of issues.
 - h. Other reports required by commissioning process.
 - i. List unresolved issues and reasons they remain unresolved and should be exempted from the requirements for Construction-Phase Commissioning Completion.
 - j. Report shall include commissioning work of Contractor.
- B. Operation and Maintenance Data: For proprietary test equipment, instrumentation, and tools to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Commissioning Coordinator Qualifications:
 - 1. Documented experience commissioning systems of similar complexity to those contained in these documents on at least three projects of similar scope and complexity.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

- A. Test equipment and instrumentation required to perform the commissioning process shall remain the property of Contractor unless otherwise indicated.
- B. Test equipment and instrumentation required to perform commissioning process shall comply with the following criteria:
 - 1. Be manufactured for the purpose of testing and measuring tests for which they are being used and have an accuracy to test and measure system performance within the tolerances required to determine acceptable performance.

2. Calibrated and certified.
 - a. Calibration performed and documented by a qualified calibration agency according to national standards applicable to the tools and instrumentation being calibrated. Calibration shall be current according to national standards or within test equipment and instrumentation manufacturer's recommended intervals, whichever is more frequent, but not less than within six months of initial use on Project. Calibration tags shall be permanently affixed.
 - b. Repair and recalibrate test equipment and instrumentation if dismantled, dropped, or damaged since last calibrated.
3. Maintain test equipment and instrumentation.
4. Use test equipment and instrumentation only for testing or monitoring Work for which they are designed.

2.2 PROPRIETARY TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

- A. Proprietary test equipment, instrumentation, and tools are those manufactured or prescribed by tested equipment manufacturer and required for work on its equipment as a condition of equipment warranty, or as otherwise required to service, repair, adjust, calibrate, or perform work on its equipment.
 1. Identify proprietary test equipment, instrumentation, and tools required in the test equipment identification list submittal.
 2. Proprietary test equipment, instrumentation, and tools shall become the property of Owner at Substantial Completion.

2.3 REPORT FORMAT AND ORGANIZATION

- A. General Format and Organization:
 1. Bind report in three-ring binders.
 2. Label the front cover and spine of each binder with the report title, volume number, project name, Contractor's name, and date of report.
 3. Electronic Data: Portable document format (PDF); a single file with outline-organized bookmarks for major and minor tabs and tab contents itemized for specific reports.
- B. Commissioning Report:
 1. Include a table of contents and an index to each test.
 2. Include major tabs for each Specification Section.
 3. Include minor tabs for each test.
 4. Within each minor tab, include the following:
 - a. Test specification.
 - b. Pre-startup reports.
 - c. Approved test procedures.
 - d. Test data forms, completed and signed.
 - e. Commissioning issue reports, showing resolution of issues, and documentation related to resolution of issues pertaining to a single test. Group data forms, commissioning issue reports showing resolution of issues, and documentation related to resolution of issues for each test repetition together within the minor tab, in reverse chronological order (most recent on top).

PART 3 - EXECUTION

3.1 PREPARATION

- A. Review preliminary construction checklists and preliminary test procedures and data forms.

3.2 CONSTRUCTION CHECKLISTS

- A. Construction checklists cannot modify or conflict with the Contract Documents.
- B. Create construction checklists based on actual systems and equipment to be included in Project.
- C. Material Checks: Compare specified characteristics and approved submittals with materials as received. Include factory tests and other evaluations, adjustments, and tests performed prior to shipment if applicable.
 - 1. Service connection requirements, including configuration, size, location, and other pertinent characteristics.
 - 2. Included optional features.
 - 3. Delivery Receipt Check: Inspect and record physical condition of materials and equipment on delivery to Project site, including agreement with approved submittals, cleanliness, and lack of damage.
 - 4. Installation Checks:
 - a. Location according to Drawings and approved Shop Drawings.
 - b. Configuration.
 - c. Compliance with manufacturers' written installation instructions.
 - d. Attachment to structure.
 - e. Access clearance to allow for maintenance, service, repair, removal, and replacement without the need to disassemble or remove other equipment or building elements. Access coordinated with other building elements and equipment, including, but not limited to, ceiling and wall access panels, in a manner consistent with OSHA fall-protection regulations and safe work practices.
 - f. Utility connections are of the correct characteristics, as applicable.
 - g. Correct labeling and identification.
 - h. Startup Checks: Verify readiness of equipment to be energized. Include manufacturer's standard startup procedures and forms.
- D. Startup: Perform and document initial operation of equipment to prove that it is installed properly and operates as intended according to manufacturer's standard startup procedures, at minimum.
- E. Performance Tests:
 - 1. Static Tests: As specified elsewhere, including, but not limited to, duct and pipe leakage tests, insulation-resistance tests, and water-penetration tests.
 - 2. Component Performance Tests: Tests evaluate the performance of an input or output of components under a full range of operating conditions.
 - 3. Equipment and Assembly Performance Tests: Test and evaluate performance of equipment and assemblies under a full range of operating conditions and loads.

4. System Performance Tests: Test and evaluate performance of systems under a full range of operating conditions and loads.
 5. Intersystem Performance Tests: Test and evaluate the interface of different systems under a full range of operating conditions and loads.
- F. Deferred Construction Checklists: Obtain Owner approval of proposed deferral of construction checklists, including proposed schedule of completion of each deferred construction checklist, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. When approved, deferred construction checklists may be completed after date of Construction-Phase Commissioning Completion. Include the following in a request for Certificate of Construction-Phase Commissioning Process Completion:
1. Identify deferred construction checklists by number and title.
 2. Provide a target schedule for completion of deferred construction checklists.
 3. Written approval of proposed deferred construction checklists, including approved schedule of completion of each deferred construction checklist.
- G. Delayed Construction Checklists: Obtain Owner approval of proposed delayed construction checklists, including proposed schedule of completion of each delayed construction checklist, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. When approved, delayed construction checklists may be completed after date of Construction-Phase Commissioning Completion. Include the following in a request for Certificate of Construction-Phase Commissioning Process Completion:
1. Identify delayed construction checklist by construction checklist number and title.
 2. Provide a target schedule for completion of delayed construction checklists.
 3. Written approval of proposed delayed construction checklists, including approved schedule of completion of each delayed construction checklist.

3.3 GENERAL EXECUTION REQUIREMENTS

- A. Schedule and coordinate commissioning process with the Construction Schedule.
- B. Perform activities identified in construction checklists, including tests, and document results of actions as construction proceeds.
- C. Perform test demonstrations for Owner's witness. Unless otherwise indicated, demonstrate tests for 100 percent of work to which the test applies. In some instances, demonstration of a random sample of other than 100 percent of the results of a test is specified.
 1. Where sampling is specified, the sampling plan and procedure for the test demonstration shall be determined using ASQ Z1.4.
 2. The "lot size" in ASQ Z1.4 is the sum of the number of items to which the test demonstration applies, as described in the scope subparagraph of each test.
 3. On determination of the sample size, the samples shall be selected randomly by Owner's witness at the time of the test demonstration.
 4. Include in the Commissioning Plan a detailed list of the test demonstrations with lot and sample quantities for each test.
- D. Report test data and commissioning issue resolutions.

- E. Schedule personnel to participate in and perform Commissioning-Process Work.
- F. Installing contractors' commissioning responsibilities include, but are not limited to, the following:
 - 1. Operating the equipment and systems they install during tests.
 - 2. In addition, installing contractors may be required to assist in tests of equipment and systems with which their work interfaces.

3.4 COMMISSIONING COORDINATOR RESPONSIBILITIES

- A. Management and Coordination: Manage, schedule, and coordinate commissioning process, including, but not limited to, the following:
 - 1. Coordinate with subcontractors on their commissioning responsibilities and activities.
 - 2. Obtain, assemble, and submit commissioning documentation.
 - 3. Attend periodic on-site commissioning meetings.
 - 4. Develop and maintain the commissioning schedule. Integrate commissioning schedule into the Construction Schedule. Update Construction Schedule at specified intervals.
 - 5. Review and comment on preliminary test procedures and data forms.
 - 6. Report inconsistencies and issues in system operations.
 - 7. Verify that tests have been completed and results comply with acceptance criteria, and that equipment and systems are ready before scheduling test demonstrations.
 - 8. Direct and coordinate test demonstrations.
 - 9. Coordinate witnessing of test demonstrations by Owner's witness.
 - 10. Coordinate and manage training. Be present during training sessions to direct video recording, present training, and direct the training presentations of others.
 - 11. Prepare and submit specified commissioning reports.
 - 12. Track commissioning issues until resolution and retesting is successfully completed.
 - 13. Retain original records of Commissioning-Process Work, organized as required for the commissioning report. Provide Owner's representative access to these records on request.
 - 14. Assemble and submit commissioning report.

3.5 COMMISSIONING TESTING

- A. Quality Control: Construction checklists, including tests, are quality-control tools designed to improve the functional quality of Project. Test demonstrations evaluate the effectiveness of Contractor's quality-control process.
- B. Owner's witness will be present to witness commissioning work requiring the signature of an owner's witness, including, but not limited to, test demonstrations. Owner's project manager will coordinate attendance by Owner's witness with Contractor's published Commissioning Schedule. Owner's witness will provide no labor or materials in the commissioning work. The only function of Owner's witness will be to observe and comment on the progress and results of commissioning process.

- C. Construction Checklists:
1. Complete construction checklists as Work is completed.
 2. Distribute construction checklists to installing contractors before they start work.
 3. Installers:
 - a. Verify installation using approved construction checklists as Work proceeds.
 - b. Complete and sign construction checklists weekly for work performed during the preceding week.
 4. Provide Commissioning Authority access to construction checklists.
- D. Installation Compliance Issues: Record as an installation compliance issue Work found to be incomplete, inaccessible, at variance with the Contract Documents, nonfunctional, or that does not comply with construction checklists. Record installation compliance issues on the construction checklist at the time they are identified. Record corrective action and how future Work should be modified before signing off the construction checklist.
- E. Pre-Startup Audit: Prior to executing startup procedures, review completed installation checks to determine readiness for startup and operation. Report conditions, which, if left uncorrected, adversely impact the ability of systems or equipment to operate satisfactorily or to comply with acceptance criteria. Prepare pre-startup report for each system.
- F. Test Procedures and Test Data Forms:
1. Test procedures shall define the step-by-step procedures to be used to execute tests and test demonstrations.
 2. Test procedures shall be specific to the make, model, and application of the equipment and systems being tested.
 3. Completed test data forms are the official records of the test results.
 4. Commissioning Authority will provide to Contractor preliminary test procedures and test data forms for performance tests and commissioning tests after approval of Product Data, Shop Drawings, and preliminary operation and maintenance manual.
 5. Review preliminary test procedures and test data forms, and provide comments within 14 days of receipt from Commissioning Authority. Review shall address the following:
 - a. Equipment protection and warranty issues, including, but not limited to, manufacturers' installation and startup recommendations, and operation and maintenance instructions.
 - b. Applicability of the procedure to the specific software, equipment, and systems approved for installation.
 6. After Contractor has reviewed and commented on the preliminary test procedures and test data forms, Commissioning Authority will revise and reissue the approved revised test procedures and test data forms marked "Approved for Testing."
 7. Use only approved test procedures and test data forms marked "Approved for Testing" to perform and document tests and test demonstrations.

G. Performance of Tests:

1. The sampling rate for tests is 100 percent. The sampling rate for test demonstrations is 100 percent unless otherwise indicated.
2. Perform and complete each step of the approved test procedures in the order listed.
3. Record data observed during performance of tests on approved data forms at the time of test performance and when the results are observed.
4. Record test results that are not within the range of acceptable results on commissioning issue report forms in addition to recording the results on approved test procedures and data forms according to the "Commissioning Compliance Issues" Paragraph in this Article.
5. On completion of a test, sign the completed test procedure and data form. Tests for which test procedures and data forms are incomplete, not signed, or which indicate performance that does not comply with acceptance criteria will be rejected. Tests for which test procedures and data forms are rejected shall be repeated and results resubmitted.

H. Performance of Test Demonstration:

1. Perform test demonstrations on a sample of tests after test data submittals are approved. The sampling rate for test demonstrations shall be 100 percent unless otherwise indicated in the individual test specification.
 - a. Notify Owner's witness at least 5 working days in advance of each test demonstration.
2. Perform and complete each step of the approved test procedures in the order listed.
3. Record data observed during performance of test demonstrations on approved data forms at the time of demonstration and when the results are observed.
4. Provide full access to Owner's witness to directly observe the performance of all aspects of system response during the test demonstration. On completion of a test demonstration, sign the completed data form and obtain signature of Owner's witness at the time of the test to authenticate the reported results.
5. Test demonstration data forms not signed by Contractor and Owner's witness at the time of the completion of the procedure will be rejected. Test demonstrations for which data forms are rejected shall be repeated and results shall be resubmitted.
 - a. Exception for Failure of Owner's Witness to Attend: Failure of Owner's witness to be present for agreed-on schedule of test demonstration shall not delay Contractor. If Owner's witness fails to attend a scheduled test, Contractor shall proceed with scheduled test. On completion, Contractor shall sign the data form for Contractor and for Owner's witness, and shall note the absence of Owner's witness at the scheduled time and place.
6. False load test requirements are specified in related sections.
 - a. Where false load testing is specified, provide temporary equipment, power, controls, wiring, piping, valves, and other necessary equipment and connections required to apply the specified load to the system. False load system shall be capable of steady-state operation and modulation at the level of load specified. Equipment and systems permanently installed in this work shall not be used to create the false load without Architect's written approval.

I. Deferred Tests:

1. Deferred Test List: Identify, in the request for Certificate of Construction-Phase Commissioning Process Completion, proposed deferred tests or other tests approved for deferral until specified seasonal or other conditions are available. When approved, deferred tests may be completed after the date of Construction-Phase Commissioning Completion. Identify proposed deferred tests in the request for Certificate of Construction-Phase Commissioning Process Completion as follows:
 - a. Identify deferred tests by number and title.
 - b. Provide a target schedule for completion of deferred tests.
2. Schedule and coordinate deferred tests. Schedule deferred tests when specified conditions are available.
 - a. Notify Architect and Commissioning Authority at least 5 working days (minimum) in advance of tests.
3. Where deferred tests are specified, coordinate participation of necessary personnel and of Architect, Commissioning Authority, and Owner's witness. Schedule deferred tests to minimize occupant and facility impact. Obtain Architect's approval of the proposed schedule.

J. Delayed Tests:

1. Delayed Test List: Identify, in the request for Certificate of Construction-Phase Commissioning Process Completion, proposed delayed tests. Obtain Owner approval of proposed delayed tests, including proposed schedule of completion of each delayed test, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. Include the following in the request for Certificate of Construction-Phase Commissioning Process Completion:
 - a. Identify delayed tests by test number and title.
 - b. Written approval of proposed delayed tests, including approved schedule of completion of delayed tests.
2. Schedule and coordinate delayed tests. Schedule delayed tests when conditions that caused the delay have been rectified.
 - a. Notify Architect and Commissioning Authority at least 5 working days (minimum) in advance of tests.
3. Where delayed tests are approved, coordinate participation of necessary personnel and of Architect, Commissioning Authority, and Owner's witness. Schedule delayed tests to minimize occupant and facility impact. Obtain Architect's approval of the proposed schedule.

K. Commissioning Compliance Issues:

1. Test results that are not within the range of acceptable results are commissioning compliance issues.
2. Track and report commissioning compliance issues until resolution and retesting are successfully completed.
3. If a test demonstration fails, determine the cause of failure. Direct timely resolution of issue and then repeat the demonstration. If a test demonstration must be repeated due to failure caused by Contractor work or materials, reimburse Owner for billed costs for the participation in the repeated demonstration.

4. Test Results: If a test demonstration fails to meet the acceptance criteria, perform the following:
 - a. Complete a commissioning compliance issue report form promptly on discovery of test results that do not comply with acceptance criteria.
 - 1) Submit commissioning compliance issue report form within 48 hours of the test.
 - b. Determine the cause of the failure.
 - c. Establish responsibility for corrective action if the failure is due to conditions found to be Contractor's responsibility.
5. Commissioning Compliance Issue Report: Provide a commissioning compliance issue report for each issue. Do not report multiple issues on the same commissioning compliance issue report.
 - a. Exception: If an entire class of devices is determined to exhibit the identical issue, they may be reported on a single commissioning compliance issue report. (For example, if all return-air damper actuators that are specified to fail to the open position are found to fail to the closed position, they may be reported on a single commissioning issue report. If a single commissioning issue report is used for multiple commissioning compliance issues, each device shall be identified in the report, and the total number of devices at issue shall be identified.
 - b. Complete and submit Part 1 of the commissioning compliance issue report immediately when the condition is observed.
 - c. Record the commissioning compliance issue report number and describe the deficient condition on the data form.
 - d. Resolve commissioning compliance issues promptly. Complete and submit Part 2 of the commissioning compliance issue report when issues are resolved.
6. Diagnose and correct failed test demonstrations as follows:
 - a. Perform diagnostic tests and activities required to determine the fundamental cause of issues observed.
 - b. Record each step of the diagnostic procedure prior to performing the procedure. Update written procedure as changes become necessary.
 - c. Record the results of each step of the diagnostic procedure.
 - d. Record the conclusion of the diagnostic procedure on the fundamental cause of the issue.
 - e. Determine and record corrective measures.
 - f. Include diagnosis of fundamental cause of issues in commissioning compliance issue report.
7. Retest:
 - a. Schedule and repeat the complete test procedure for each test demonstration for which acceptable results are not achieved. Obtain signature of Owner's witness on retest data forms. Repeat test demonstration until acceptable results are achieved. Except for issues that are determined to result from design errors or omissions, or other conditions beyond Contractor's responsibility, compensate Owner for direct costs incurred as the result of repeated test demonstrations to achieve acceptable results.
 - b. For each repeated test demonstration, submit a new test data form, marked "Retest."

8. Do not correct commissioning compliance issues during test demonstrations.
 - a. Exceptions will be allowed if the cause of the issue is obvious and resolution can be completed in less than five minutes. If corrections are made under this exception, note the deficient conditions on the test data form and issue a commissioning compliance issue report. A new test data form, marked "Retest," shall be initiated after the resolution has been completed.

3.6 COMMISSIONING MEETINGS

- A. Commissioning Authority will schedule and conduct commissioning meetings

3.7 SEQUENCING

- A. Sequencing of Commissioning Verification Activities: For a particular material, item of equipment, assembly, or system, perform the following in the order listed unless otherwise indicated:
 1. Construction Checklists:
 - a. Material checks.
 - b. Installation checks.
 - c. Startup, as appropriate. Some startup may depend on component performance. Such startup may follow component performance tests on which the startup depends.
 - d. Performance Tests:
 - 1) Static tests, as appropriate.
 - 2) Component performance tests. Some component performance tests may depend on completion of startup. Such component performance tests may follow startup.
 - 3) Equipment and assembly performance tests.
 - 4) System performance tests.
 - 5) Intersystem performance tests.
 2. Commissioning tests.
- B. Before performing commissioning tests, verify that materials, equipment, assemblies, and systems are delivered, installed, started, and adjusted to perform according to construction checklists.
- C. Verify readiness of materials, equipment, assemblies, and systems by performing tests prior to performing test demonstrations. Notify Architect if acceptable results cannot be achieved due to conditions beyond Contractor's control or responsibility.
- D. Commence tests as soon as installation checks for materials, equipment, assemblies, or systems are satisfactorily completed. Tests of a particular system may proceed prior to completion of other systems, provided the incomplete work does not interfere with successful execution of test.

3.8 SCHEDULING

- A. Commence commissioning process as early in the construction period as possible.

- B. Commissioning Schedule: Integrate commissioning activities into Construction Schedule.
 - 1. Include detailed commissioning activities in monthly updated Construction Schedule and short-interval schedule submittals.
 - 2. Schedule the start date and duration for the following commissioning activities:
 - a. Submittals.
 - b. Preliminary operation and maintenance manual submittals.
 - c. Installation checks.
 - d. Startup, where required.
 - e. Performance tests.
 - f. Performance test demonstrations.
 - g. Commissioning tests.
 - h. Commissioning test demonstrations.
 - 3. Schedule shall include a line item for each installation check, startup, and test activity specific to the equipment or systems involved.
 - 4. Determine milestones and prerequisites for commissioning process. Show commissioning milestones, prerequisites, and dependencies in monthly updated critical-path-method construction schedule and short-interval schedule submittals.
- C. Two-Week Look-Ahead Commissioning Schedule:
 - 1. Two weeks prior to the beginning of tests, submit a detailed two-week look-ahead schedule. Thereafter, submit updated two-week look-ahead schedules weekly for the duration of commissioning process.
 - 2. Two-week look-ahead schedules shall identify the date, time, beginning location, Contractor personnel required, and anticipated duration for each startup or test activity.
 - 3. Use two-week look-ahead schedules to notify and coordinate participation of Owner's witnesses.
- D. Owner's Witness Coordination:
 - 1. Coordinate Owner's witness participation via Architect.
 - 2. Notify Architect of commissioning schedule changes at least two work days in advance for activities requiring the participation of Owner's witness.

3.9 COMMISSIONING REPORTS

- A. Test Reports:
 - 1. Pre-startup reports include observations of the conditions of installation, organized into the following sections:
 - a. Equipment Model Verification: Compare contract requirements, approved submittals, and provided equipment. Note inconsistencies.
 - b. Preinstallation Physical Condition Checks: Observe physical condition of equipment prior to installation. Note conditions including, but not limited to, physical damage, corrosion, water damage, or other contamination or dirt.
 - c. Preinstallation Component Verification Checks: Verify components supplied with the equipment, preinstalled or field installed, are correctly installed and functional. Verify external components required for proper operation of equipment correctly installed and functional. Note missing, improperly configured, improperly installed, or nonfunctional components.

- d. Summary of Installation Compliance Issues and Corrective Actions: Identify installation compliance issues and the corrective actions for each. Verify that issues noted have been corrected.
 - e. Evaluation of System Readiness for Startup: For each item of equipment for each system for which startup is anticipated, document in summary form acceptable to Owner completion of equipment model verification, preinstallation physical condition checks, preinstallation component verification checks, and completion of corrective actions for installation compliance issues.
2. Test data reports include the following:
 - a. "As-tested" system configuration. Complete record of conditions under which the test was performed, including, but not limited to, the status of equipment, systems, and assemblies; temporary adjustments and settings; and ambient conditions.
 - b. Data and observations, including, but not limited to, data trend logs, recorded during the tests.
 - c. Signatures of individuals performing and witnessing tests.
 - d. Data trend logs accumulated overnight from the previous day of testing.
3. Commissioning Compliance Issue Reports: Report as commissioning compliance issues results of tests and test demonstrations that do not comply with acceptance criteria. Report only one issue per commissioning compliance issue report. Use sequentially numbered facsimiles of commissioning compliance issue report form included in this Section, or other form approved by Owner. Distribute commissioning compliance issue reports to parties responsible for taking corrective action. Identify the following:
 - a. Commissioning compliance issue report number. Assign unique, sequential numbers to individual commissioning compliance issue reports when they are created, to be used for tracking.
 - b. Action distribution list.
 - c. Report date.
 - d. Test number and description.
 - e. Equipment identification and location.
 - f. Briefly describe observations about the performance associated with failure to achieve acceptable results. Identify the cause of failure if apparent.
 - g. Diagnostic procedure or plan to determine the cause (include in initial submittal)
 - h. Diagnosis of fundamental cause of issues as specified below (include in resubmittal).
 - i. Fundamental cause of unacceptable performance as determined by diagnostic tests and activities.
 - j. When issues have been resolved, update and resubmit the commissioning issue report forms by completing Part 2. Identify resolution taken and the dates and initials of the persons making the entries.
 - k. Schedule for retesting.
4. Weekly progress reports include information for tests conducted since the preceding report and the following:
 - a. Completed data forms.
 - b. Equipment or system tested, including test number, system or equipment tag number and location, and notation about the apparent acceptability of results.

- c. Activities scheduled but not conducted per schedule.
 - d. Commissioning compliance issue report log.
 - e. Schedule changes for remaining Commissioning-Process Work, if any.
- 5. Data trend logs shall be initiated and running prior to the time scheduled for the test demonstration.
 - a. Trend log data format shall be multiple data series graphs. Where multiple data series are trend logged concurrently, present the data on a common horizontal time axis. Individual data series may be presented on a segmented vertical axis to avoid interference of one data series with another, and to accommodate different axis scale values. Graphs shall be sufficiently clear to interpret data within the accuracy required by the acceptance criteria.
 - b. Attach to the data form printed trend log data collected during the test or test demonstration.
 - c. Record, print out, and attach to the data form operator activity during the time the trend log is running. During the time the trend log is running, operator intervention not directed by the test procedure invalidates the test results.
- 6. System Alarm Logs: Record and print out a log of alarms that occurred since the last log was printed. Evaluate alarms to determine if the previous day's work resulted in any conditions that are not considered "normal operation."
 - a. Conditions that are not considered "normal operation" shall be reported on a commissioning issue report attached to the alarm log. Resolve as necessary. The intent of this requirement is to discover control system points or sequences left in manual or disabled conditions, equipment left disconnected, set points left with abnormal values, or similar conditions that may have resulted from failure to fully restore systems to normal, automatic control after test completion.

3.10 CERTIFICATE OF CONSTRUCTION-PHASE COMMISSIONING PROCESS COMPLETION

- A. When Contractor considers that construction-phase commissioning process, or a portion thereof which Owner agrees to accept separately, is complete, Contractor shall prepare and submit to Owner and Commissioning Authority through Architect a comprehensive list of items to be completed or corrected. Failure to include an item on such list does not alter Contractor's responsibility to complete commissioning process.
- B. On receipt of Contractor's list, Commissioning Authority will make an inspection to determine whether the construction-phase commissioning process or designated portion thereof is complete. If Commissioning Authority's inspection discloses items, whether included on Contractor's list, which is not sufficiently complete as defined in "Construction-Phase Commissioning Process Completion" Paragraph in the "Definitions" Article, Contractor shall, before issuance of the Certificate of Construction-Phase Commissioning Process Completion, complete or correct such items on notification by Commissioning Authority. In such case, Contractor shall then submit a request for another inspection by Commissioning Authority to determine construction-phase commissioning process completion.

- C. Contractor shall promptly correct deficient conditions and issues discovered during commissioning process. Costs of correcting such deficient conditions and issues, including additional testing and inspections, the cost of uncovering and replacement, and compensation for Architect's and Commissioning Authority's services and expenses made necessary thereby, shall be at Contractor's expense.
- D. When construction-phase commissioning process or designated portion is complete, Commissioning Authority will prepare a Certificate of Construction-Phase Commissioning Process Completion that shall establish the date of completion of construction-phase commissioning process. Certificate of Construction-Phase Commissioning Process Completion shall be submitted prior to requesting inspection for determining date of Substantial Completion.

END OF SECTION 01 9113

SECTION 02 4119 - SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section Includes:
 - 1. Demolition and removal of selected portions of exterior or interior of building or structure and site elements.
 - 2. Removal and salvage of existing items for delivery to Owner and removal of existing items for reinstallation.
- B. Related Requirements:
 - 1. Section 01 5639 "Temporary Tree and Plant Protection" for temporary protection of existing trees and plants that are affected by selective demolition.

1.2 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of off-site unless indicated to be removed and salvaged or removed and reinstalled.
- B. Remove and Salvage: Detach items from existing construction, in a manner to prevent damage, and deliver to Owner as indicated.
- C. Remove and Reinstall: Detach items from existing construction, in a manner to prevent damage; prepare for reuse; and reinstall where indicated.
- D. Existing to Remain: Existing items of construction that are not to be removed.

1.3 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
 - 1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.4 COORDINATION

- A. Arrange selective demolition schedule so as not to interfere with Owner's operations.

1.5 INFORMATIONAL SUBMITTALS

- A. Survey of Existing Conditions: Submit survey.

- B. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
- C. Schedule of Selective Demolition Activities: Indicate the following:
 - 1. Detailed sequence of selective demolition and removal work, with starting and ending dates for each activity. Ensure Owner's on-site operations are uninterrupted.
 - 2. Temporary interruption of utility services. Indicate how long utility services will be interrupted.
 - 3. Coordination for shutoff, capping, and continuation of utility services.
 - 4. Use of elevator and stairs.
 - 5. Coordination of Owner's continuing occupancy of portions of existing building and of Owner's partial occupancy of completed Work.
- D. Warranties: Documentation indicating that existing warranties are still in effect after completion of selective demolition.

1.6 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.

1.7 FIELD CONDITIONS

- A. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- B. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.
- C. Hazardous Materials:
 - 1. It is not expected that hazardous materials will be encountered in the Work.
 - a. Hazardous materials will be removed by Owner before start of the Work.
 - b. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
- D. On-site sale of removed items or materials is not permitted.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning selective demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ANSI/ASSP A10.6 and NFPA 241.

- C. Sustainable Design Requirements for Building Reuse:
 - 1. Maintain the existing building structural systems where indicated to remain. Do not demolish such existing construction beyond indicated limits.
 - 2. Maintain the existing interior ceilings, interior partitions, and/or demountable walls where indicated to remain. Do not demolish such existing construction beyond indicated limits.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting selective demolition operations.
- B. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs or video.
 - 1. Inventory and record the condition of items to be removed for salvage or reinstallation. Photograph or video conditions that might be misconstrued as damage caused by removal.
 - 2. Photograph or video existing conditions of adjoining construction including finish surfaces, that might be misconstrued as damage caused by selective demolition operations or removal of items for salvage or reinstallation.

3.2 PREPARATION

- A. Temporary Shoring: Design, provide, and maintain shoring, bracing, and structural supports as required to preserve stability and prevent movement, settlement, or collapse of construction and finishes to remain, and to prevent unexpected or uncontrolled movement or collapse of construction being demolished.
 - 1. Strengthen or add new supports when required during progress of selective demolition.
- B. Temporary Protection: Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - 1. Provide protection to ensure safe passage of people around selective demolition area and to and from occupied portions of building.
 - 2. Provide temporary weather protection, during interval between selective demolition of existing construction on exterior surfaces and new construction, to prevent water leakage and damage to structure and interior areas.
 - 3. Protect walls, ceilings, floors, and other existing finish work that are to remain or that are exposed during selective demolition operations.
 - 4. Cover and protect furniture, furnishings, and equipment that have not been removed.
- C. Existing Items to Remain: Protect construction indicated to remain against damage and soiling during selective demolition. When permitted by Architect, items may be removed to a suitable, protected storage location and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.3 UTILITY SERVICES AND BUILDING SYSTEMS

- A. Existing Services/Systems to Remain: Maintain utilities and building systems and equipment to remain and protect against damage during selective demolition operations.
1. Maintain fire-protection facilities in service during selective demolition operations.
 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
 3. Arrange to shut off utilities with utility companies.
 4. If disconnection of utilities and building systems will affect adjacent occupied parts of the building, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to those parts of the building.
 5. Demolish and remove existing building systems, equipment, and components indicated on Drawings to be removed.
 - a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - b. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - c. Equipment to Be Removed: Disconnect and cap services and remove equipment and components.
 6. Abandon existing building systems, equipment, and components indicated on Drawings to be abandoned in place.
 - a. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
 - b. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.
 7. Remove and reinstall/salvage existing building systems, equipment, and components indicated on drawings to be removed and reinstalled or removed and salvaged:
 - a. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment and components; when appropriate, reinstall, reconnect, and make equipment operational.
 - b. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and components and deliver to Owner.

3.4 SALVAGE/REINSTALL

- A. Removed and Salvaged Items:
1. Clean salvaged items.
 2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
 3. Store items in a secure area until delivery to Owner.
 4. Transport items to Owner's storage area designated by Owner.
 5. Protect items from damage during transport and storage.
- B. Removed and Reinstalled Items:
1. Clean and repair items to functional condition adequate for intended reuse.
 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 3. Protect items from damage during transport and storage.

4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

3.5 SELECTIVE DEMOLITION, GENERAL

- A. General: Demolish and remove existing construction only to extent required by new construction and as indicated. Use methods required to complete the Work within limitations of governing regulations and as follows:
 1. Proceed with selective demolition systematically, from higher to lower level. Complete selective demolition operations above each floor or tier before disturbing supporting members on the next lower level.
 2. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods least likely to damage construction to remain or adjoining construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.
 3. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
 4. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
 5. Maintain fire watch during and for at least 2 hours after flame-cutting operations.
 6. Maintain adequate ventilation when using cutting torches.
 7. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
 8. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
 9. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
- B. Site Access and Temporary Controls: Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 1. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed trafficways if required by authorities having jurisdiction.
 2. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.

3.6 SELECTIVE DEMOLITION PROCEDURES FOR SPECIFIC MATERIALS

- A. Concrete:
 1. Demolish in sections. Cut concrete full depth at junctures with construction to remain and at regular intervals using power-driven saw and then remove concrete between saw cuts.

- B. Masonry: Demolish in small sections. Cut masonry at junctures with construction to remain, using power-driven saw, and then remove masonry between saw cuts.
- C. Concrete Slabs-on-Grade: Saw-cut perimeter of area to be demolished and then break up and remove.
- D. Resilient Floor Coverings: Remove floor coverings and adhesive in accordance with recommendations in RFCI's "Recommended Work Practices for the Removal of Resilient Floor Coverings." Do not use methods requiring solvent-based adhesive strippers.

3.7 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and dispose of them in an EPA-approved construction and demolition waste landfill acceptable to authorities having jurisdiction.
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
 - 3. Remove debris from elevated portions of building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
- B. Burning: Do not burn demolished materials.

3.8 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by selective demolition operations. Return adjacent areas to condition existing before selective demolition operations began.

END OF SECTION 02 4119

SECTION 03 1000 - CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Form-facing materials.

1.2 DEFINITIONS

- A. Form-Facing Material: The temporary form materials that come in direct contact with the concrete as part of the formwork components in supporting the concrete while the concrete is setting and gaining sufficient strength to be self-supporting. The most common materials are steel, aluminum, and wood.
- B. Formwork: The total system of support of freshly placed concrete, including the mold or sheathing that contacts the concrete, as well as supporting members, hardware, and necessary bracing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Concrete Formwork: Design, engineer, erect, shore, brace, and maintain formwork, shores, and reshores in accordance with ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.
 - 1. Design wood panel forms in accordance with APA's "Concrete Forming Design/Construction Guide."
 - 2. Design formwork to limit deflection of form-facing material to 1/240 of center-to-center spacing of supports.

2.2 FORM-FACING MATERIALS

- A. As-Cast Surface Form-Facing Material:
 - 1. Provide continuous, true, and smooth concrete surfaces.
 - 2. Furnish in largest practicable sizes to minimize number of joints.
 - 3. Acceptable Materials: As required to comply with Surface Finish designations specified in Section 03 3000 "Cast-in-Place Concrete, and as follows:
 - a. Plywood, metal, or other approved panel materials.
 - b. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:
 - 1) APA HDO (high-density overlay).
- B. Concealed Surface Form-Facing Material: Lumber, plywood, metal, plastic, or another approved material.
 - 1. Provide lumber dressed on at least two edges and one side for tight fit.

2.3 RELATED MATERIALS

- A. Chamfer Strips: Wood, metal, PVC, or rubber strips, 3/4 by 3/4 inch, minimum.
- B. Rustication Strips: Wood, metal, PVC, or rubber strips, kerfed for ease of form removal.
- C. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.
 - 1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
 - 2. Form release agent for form liners to be acceptable to form liner manufacturer.
- D. Form Ties: Factory-fabricated, removable or snap-off, glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
- E. Sealant: One-part moisture cure silicone sealant used with form liners.

PART 3 - EXECUTION

3.1 INSTALLATION OF FORMWORK

- A. Comply with ACI 301.
- B. Construct formwork, so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117 and to comply with the Surface Finish designations specified in Section 03 3000 "Cast-in-Place Concrete" for as-cast finishes.
- C. Limit concrete surface irregularities as follows:
 - 1. Surface Finish-1.0: ACI 117 Class D, 1 inch.
- D. Construct forms tight enough to prevent loss of concrete mortar.
 - 1. Minimize joints.
 - 2. Exposed Concrete: Symmetrically align joints in forms.
- E. Construct removable forms for easy removal without hammering or prying against concrete surfaces.
 - 1. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces.
 - 2. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - 3. Install keyways, reglets, recesses, and other accessories, for easy removal.
- F. Do not use rust-stained, steel, form-facing material.
- G. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces.
 - 1. Provide and secure units to support screed strips
 - 2. Use strike-off templates or compacting-type screeds.

- H. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible.
 - 1. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar.
 - 2. Locate temporary openings in forms at inconspicuous locations.
- I. Chamfer exterior corners and edges of permanently exposed concrete.
- J. At construction joints, overlap forms onto previously placed concrete not less than 12 inches.
- K. Form openings, chases, offsets, keyways, blocking, screeds, and bulkheads required in the Work.
 - 1. Determine sizes and locations from trades providing such items.
 - 2. Obtain written approval of Architect prior to forming openings not indicated on Drawings.
- L. Construction Joints:
 - 1. Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 2. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 3. Place joints perpendicular to main reinforcement.
- M. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- N. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- O. Coat contact surfaces of forms with form-release agent, in accordance with manufacturer's written instructions, before placing reinforcement.

3.2 INSTALLATION OF EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
 - 3. Clean embedded items immediately prior to concrete placement.

3.3 REMOVING AND REUSING FORMS

- A. Formwork for sides of beams, walls, columns, and similar parts of the Work that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F for 24 hours after placing concrete. Concrete has to be hard enough to not be damaged by form-removal operations, and curing and protection operations need to be maintained.
 - 1. Leave formwork for slabs and other structural elements that support weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 - 2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- B. Clean and repair surfaces of forms to be reused in the Work.
 - 1. Split, frayed, delaminated, or otherwise damaged form-facing material are unacceptable for exposed surfaces.
 - 2. Apply new form-release agent.
- C. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints.
 - 1. Align and secure joints to avoid offsets.
 - 2. Do not use patched forms for exposed concrete surfaces unless approved by Architect.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector, if required, and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports. Refer to Statement of Special Inspections in Section 01 4533.
- B. Inspections:
 - 1. Inspect formwork for shape, location, and dimensions of the concrete member being formed.
 - 2. Inspect insulating concrete forms for shape, location, and dimensions of the concrete member being formed.
- C. Prepare test and inspection reports.

END OF SECTION 03 1000

SECTION 03 2000 - CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Steel reinforcement bars.
 - 2. Welded-wire reinforcement.

1.2 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Each type of steel reinforcement.
 - 2. Bar supports.
- B. Shop Drawings: Comply with ACI SP-066:
 - 1. Include placing drawings that detail fabrication, bending, and placement.
 - 2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.
- C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.
 - 1. Location of construction joints is subject to approval of Architect.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60, deformed.
- B. Low-Alloy Steel Reinforcing Bars: ASTM A706/A706M, deformed.
- C. Headed-Steel Reinforcing Bars: ASTM A970/A970M.
- D. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.
- E. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

2.2 REINFORCEMENT ACCESSORIES

- A. Joint Dowel Bars: ASTM A615/A615M, Grade 60, plain-steel bars, cut true to length with ends square and free of burrs.

- B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.
 - 1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:
 - a. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
- C. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch in diameter.
 - 1. Finish: Plain.

2.3 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protection of In-Place Conditions:
 - 1. Do not cut or puncture vapor retarder.
 - 2. Repair damage and reseal vapor retarder before placing concrete.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

3.2 INSTALLATION OF STEEL REINFORCEMENT

- A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.
- B. Accurately position, support, and secure reinforcement against displacement.
 - 1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
 - 2. Do not tack weld crossing reinforcing bars.
- C. Preserve clearance between bars of not less than 1 inch, not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.
- D. Provide concrete coverage in accordance with ACI 318.
- E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- F. Splices: Lap splices as indicated on Drawings.
 - 1. Bars indicated to be continuous, and all vertical bars to be lapped not less than 36 bar diameters at splices, or 24 inches, whichever is greater.
 - 2. Stagger splices in accordance with ACI 318.

- G. Install welded-wire reinforcement in longest practicable lengths.
 - 1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."
 - a. For reinforcement less than W4.0 or D4.0, continuous support spacing to not exceed 12 inches.
 - 2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches for plain wire and 8 inches for deformed wire.
 - 3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
 - 4. Lace overlaps with wire.

3.3 JOINTS

- A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 1. Place joints perpendicular to main reinforcement.
 - 2. Continue reinforcement across construction joints unless otherwise indicated.
 - 3. Do not continue reinforcement through sides of strip placements of floors and slabs.
- B. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length, to prevent concrete bonding to one side of joint.

3.4 INSTALLATION TOLERANCES

- A. Comply with ACI 117.

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector, if required, and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports. Refer to Statement of Special Inspections in Section 01 4533.
- B. Inspections:
 - 1. Steel-reinforcement placement.

END OF SECTION 03 2000

SECTION 03 3000 - CAST-IN-PLACE CONCRETE**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Concrete standards.
 - 2. Concrete materials.
 - 3. Admixtures.
 - 4. Vapor retarders.
 - 5. Curing materials.
 - 6. Accessories.
 - 7. Repair materials.
 - 8. Concrete mixture materials.
 - 9. Concrete mixture class types.
 - 10. Concrete mixing.
- B. Related Requirements:
 - 1. Section 03 1000 "Concrete Forming and Accessories" for form-facing materials, form liners, insulating concrete forms, and waterstops.
 - 2. Section 03 2000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement or blended hydraulic cement alone or in combination with one or more of the following:
 - 1. Fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.
- B. Water/Cementitious Materials (w/cm) Ratio: The ratio by weight of mixing water to cementitious materials.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Portland cement.
 - 2. Blended hydraulic cement.
 - 3. Fly ash.
 - 4. Slag cement.
 - 5. Silica fume.
 - 6. Natural or other pozzolans.
 - 7. Aggregates.
 - 8. Ground calcium carbonate and aggregate mineral fillers.
 - 9. Admixtures:
 - a. Include limitations of use. Admixtures that do not comply with reference ASTM International requirements must be submitted with test data for approval.

10. Vapor retarders.
 11. Curing materials.
 12. Joint fillers.
 13. Repair materials.
- B. Design Mixtures: For each concrete mixture, include the following:
1. Mixture identification.
 2. Compressive strength at 28 days or other age as specified.
 3. Compressive strength required at stages of construction.
 4. Maximum w/cm ratio.
 5. Slump or slump flow limit.
 6. Air content.
 7. Nominal maximum aggregate size.
 8. Intended placement method.
 9. Submit adjustments to design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant changes.
- C. Concrete Schedule: For each location of each class of concrete indicated in "Concrete Mixture Class Types" Article, including the following:
1. Concrete class designation.
 2. Location within Project.
 3. Formed surface finish designation and final finish.
 4. Final finish for floors.
 5. Floor treatment, if any.

1.4 QUALITY ASSURANCE

- A. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
- B. Laboratory Testing Agency Qualifications: A testing agency qualified in accordance with ASTM C1077 and ASTM E329 for testing that performs duties on behalf of the Architect/Engineer.
- C. Field Quality-Control Testing Agency Qualifications: An independent agency, qualified in accordance with ASTM C1077 and ASTM E329 for testing indicated.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Comply with ASTM C94/C94M and ACI 301.

1.6 FIELD CONDITIONS

- A. Hot-Weather Placement: Comply with ACI 301 and ACI 305.1, and as follows:
1. Maintain concrete temperature at time of discharge to not exceed 95 deg F.
 2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS**2.1 CONCRETE STANDARDS**

- A. ACI Publications: Comply with ACI 301 unless modified by requirements in the Contract Documents.

2.2 CONCRETE MATERIALS

- A. Source Limitations:
 - 1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
 - 2. Obtain each type of admixture from single source from single manufacturer.
- B. Cementitious Materials:
 - 1. Portland Cement: ASTM C150/C150M, Type I, gray.
 - 2. Blended Hydraulic Cement: ASTM C595/C595M, Type IL, portland-limestone cement.
 - 3. Pozzolans: ASTM C618, Class C, F, or N.
 - 4. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 - 5. Ground Glass Pozzolan: ASTM C1866/C1866M, Type GS or GE.
 - 6. Silica Fume: ASTM C1240.
- C. Normal-Weight Aggregates:
 - 1. Coarse Aggregate: ASTM C33/C33M, Class 1N
 - 2. Maximum Coarse-Aggregate Size: 1 inches nominal.
 - 3. Fine Aggregate: ASTM C33/C33M.

2.3 ADMIXTURES

- A. Air-Entraining Admixture: ASTM C260/C260M.
- B. Chemical Admixtures: Do not use calcium chloride or admixtures containing calcium chloride.
 - 1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
 - 2. Retarding Admixture: ASTM C494/C494M, Type B.
 - 3. Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
 - 5. High-Range, Water-Reducing and -Retarding Admixture: ASTM C494/C494M, Type G.
 - 6. Admixtures with special properties, with documentation of claimed performance enhancement, ASTM C494/C494M, Type S.
- C. Mixing Water for Concrete Mixtures and Water Used to Make Ice: ASTM C1602/C1602M. Include documentation of compliance with limits for alkalis, sulfates, chlorides, or solids content of mixing water from Table 2 in ASTM C1602/C1602M.

2.4 VAPOR RETARDERS

- A. Sheet Vapor Retarder, Class A: ASTM E1745, Class A. Include manufacturer's recommended thickness and adhesive or pressure-sensitive tape.

2.5 CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
- B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. when dry.
- C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.
 - 1. Color:
 - a. Ambient Temperature Below 50 deg F (10 deg C): Black.
 - b. Ambient Temperature between 50 and 85 deg F (10 and 29 deg C): Any color.
 - c. Ambient Temperature Above 85 deg F (29 deg C): White.
- D. Curing Paper: 8 ft. wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.
- E. Water: Potable water that does not cause staining of the surface.
- F. Clear, Waterborne, Membrane-Forming, Dissipating Curing Compound: ASTM C309, Type 1, Class B.

2.6 ACCESSORIES

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork.
- B. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

2.7 REPAIR MATERIALS

- A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch and that can be feathered at edges to match adjacent floor elevations.
 - 1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
 - 2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
 - 3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch or coarse sand, as recommended by underlayment manufacturers.
 - 4. Compressive Strength: Not less than 4100 psi at 28 days when tested in accordance with ASTM C109/C109M.

2.8 CONCRETE MIXTURE MATERIALS

- A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301.
 - 1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland or hydraulic cement in concrete assigned to Exposure Class F3 as follows:
 - 1. Fly Ash or Other Pozzolans: 25 percent by mass.
 - 2. Slag Cement: 50 percent by mass.
 - 3. Silica Fume: 10 percent by mass.
 - 4. Total of Fly Ash or Other Pozzolans, Slag Cement, and Silica Fume: 50 percent by mass, with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
 - 5. Total of Fly Ash or Other Pozzolans and Silica Fume: 35 percent by mass with fly ash or pozzolans not exceeding 25 percent by mass and silica fume not exceeding 10 percent by mass.
- C. Admixtures: Use admixtures in accordance with manufacturer's written instructions.

2.9 CONCRETE MIXTURE CLASS TYPES

- A. Class B: Normal-weight concrete used for interior slabs-on-ground.
 - 1. Exposure Class: ACI 318 Class F0.
 - 2. Minimum Compressive Strength: 4000 psi at 28 days.
 - 3. Maximum w/cm Ratio: 0.50.
 - 4. Air Content:
 - a. Do not use an air-entraining admixture or allow total air content to exceed 3 percent for concrete used in trowel-finished floors.

2.10 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M and furnish delivery ticket.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Verification of Conditions:
 - 1. Before placing concrete, verify that installation of concrete forms, accessories, reinforcement, and embedded items is complete and that required inspections have been performed.
 - 2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:
 - 1. Daily access to the Work.
 - 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 - 3. Secure space for storage, initial curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
 - 4. Security and protection for test samples and for testing and inspection equipment at Project site.

3.3 TOLERANCES

- A. Comply with ACI 117.

3.4 INSTALLATION OF EMBEDDED ITEMS

- A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.
 - 1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3.5 INSTALLATION OF VAPOR RETARDERS

- A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.
 - 1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
 - 2. Face laps away from exposed direction of concrete pour.
 - 3. Lap vapor retarder over footings and grade beams not less than 6 inches, sealing vapor retarder to concrete.
 - 4. Lap joints 6 inches and seal with manufacturer's recommended tape.
 - 5. Terminate vapor retarder at the top of floor slabs, grade beams, and pile caps, sealing entire perimeter to floor slabs, grade beams, foundation walls, or pile caps.
 - 6. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
 - 7. Protect vapor retarder during placement of reinforcement and concrete.
 - a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches on all sides and sealing to vapor retarder.

3.6 INSTALLATION OF CAST-IN-PLACE CONCRETE

- A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.
 - 1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.

2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.
- B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.
- C. Water addition in transit or at the Project site must be in accordance with ASTM C94/C94M and must not exceed the permitted amount indicated on the concrete delivery ticket.
- D. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.
 1. Do not place concrete floors and slabs in a checkerboard sequence.
 2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
 3. Maintain reinforcement in position on chairs during concrete placement.
 4. Screed slab surfaces with a straightedge and strike off to correct elevations.
 5. Level concrete, cut high areas, and fill low areas.
 6. Slope surfaces uniformly to drains where required.
 7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.
 8. Do not further disturb slab surfaces before starting finishing operations.

3.7 INSTALLATION OF JOINTS

- A. Construct joints true to line, with faces perpendicular to surface plane of concrete.
- B. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:
 1. Grooved Joints: Form control joints after initial floating by grooving and finishing each edge of joint to a radius of 1/8 inch. Repeat grooving of control joints after applying surface finishes. Eliminate groover tool marks on concrete surfaces.
 2. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.
- C. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 1. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface unless otherwise indicated on Drawings.
 2. Terminate full-width joint-filler strips not less than 1/2 inch or more than 1 inch below finished concrete surface, where joint sealants, specified in Section 07 9200 "Joint Sealants," are indicated.
 3. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.

- D. Doweled Joints:
1. Install dowel bars and support assemblies at joints where indicated on Drawings.
 2. Lubricate or asphalt coat one-half of dowel bar length to prevent concrete bonding to one side of joint.

3.8 APPLICATION OF FINISHING FLOORS AND SLABS

- A. Float Finish:
1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
 2. Repeat float passes and restraighening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 tolerances for conventional concrete.
 3. Apply float finish to surfaces to receive trowel finish.
- B. Trowel Finish:
1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
 2. Continue troweling passes and restraighen until surface is free of trowel marks and uniform in texture and appearance.
 3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
 4. Do not add water to concrete surface. Use of an approved finishing aid is acceptable.
 5. Do not apply troweled finish to concrete, which has a total air content greater than 3 percent.
 6. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
 7. Finish surfaces to the following tolerances, in accordance with ASTM E1155, for a randomly trafficked floor surface:
 - a. Slabs on Ground:
 - 1) Specified overall values of flatness, FF 35; and of levelness, FL 25; with minimum local values of flatness, FF 24; and of levelness, FL 17.
- C. Trowel and Fine-Broom Finish: First apply a trowel finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset method. While concrete is still plastic, slightly scarify surface with a fine broom perpendicular to main traffic route.
1. Coordinate required final finish with Architect before application.
 2. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.
- D. Broom Finish: Apply a broom finish to exterior concrete platforms, steps, ramps, and locations indicated on Drawings.
1. Immediately after float finishing, slightly roughen trafficked surface by brooming with a fiber-bristle broom perpendicular to main traffic route.
 2. Coordinate required final finish with Architect before application.

3.9 APPLICATION OF FINISHING FORMED SURFACES

- A. As-Cast Surface Finishes:
1. ACI 301 (ACI 301M) Surface Finish SF-1.0: As-cast concrete texture imparted by form-facing material.
 - a. Patch voids larger than 1-1/2 inches wide or 1/2 inch deep.
 - b. Remove projections larger than 1 inch.
 - c. Tie holes do not require patching.
 - d. Surface Tolerance: ACI 117, Class D.
 - e. Apply to concrete surfaces that are buried or covered with subsequent installed surfaces.
 2. ACI 301 (ACI 301M) Surface Finish SF-2.0: As-cast concrete texture imparted by form-facing material, arranged in an orderly and symmetrical manner with a minimum of seams.
 - a. Patch voids larger than 3/4 inch wide or 1/2 inch deep.
 - b. Remove projections larger than 1/4 inch.
 - c. Patch tie holes.
 - d. Surface Tolerance: ACI 117, Class B.
 - e. Locations: Apply to concrete surfaces exposed to public view, to receive a rubbed finish, or to be covered with a coating or covering material applied directly to concrete.

3.10 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

- A. Filling in:
1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
 2. Mix, place, and cure concrete, as specified, to match color and texture with in-place construction exposed to view.
 3. Provide other miscellaneous concrete filling indicated or required to complete the Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations:
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 2. Construct concrete bases 6 inches high unless otherwise indicated on Drawings, and extend base not less than 6 inches in each direction beyond the maximum dimensions of supported equipment unless otherwise indicated on Drawings, or unless required for seismic anchor support.
 3. Minimum Compressive Strength: 4000 psi at 28 days.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete substrate.

6. Prior to pouring concrete, place and secure anchorage devices.
 - a. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - b. Cast anchor-bolt insert into bases.
 - c. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.11 APPLICATION OF CONCRETE CURING

- A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
 1. Comply with ACI 301 for cold weather protection during curing.
 2. Comply with ACI 301 and ACI 305.1 for hot-weather protection during curing.
 3. Maintain moisture loss no more than 0.2 lb/sq. ft. x h, calculated in accordance with ACI 305R, before and during finishing operations.
- B. Curing Unformed Surfaces: Comply with ACI 308.1 as follows:
 1. Begin curing after finishing concrete.
 2. Interior Concrete Floors:
 - a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:
 - 1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - a) Lap edges and ends of absorptive cover not less than 12 inches.
 - b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.
 - 2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.
 - a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
 - b) Cure for not less than seven days.
 - 3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following not in cold weather:
 - a) Water.
 - b) Continuous water-fog spray.
 - b. Floors To Receive Urethane Flooring:
 - 1) As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.
 - 2) Rewet absorptive cover, and cover immediately with polyethylene moisture-retaining cover with edges lapped 6 inches and sealed in place.
 - 3) Secure polyethylene moisture-retaining cover in place to prohibit air from circulating under polyethylene moisture-retaining cover.

- 4) Leave absorptive cover and polyethylene moisture-retaining cover in place for duration of curing period, but not less than 28 days.

3.12 INSTALLATION OF JOINT FILLING

- A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.
 1. Defer joint filling until concrete has aged at least one month(s).
- B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.
- C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches deep in formed joints.
- D. Overfill joint, and trim joint filler flush with top of joint after hardening.

3.13 INSTALLATION OF CONCRETE SURFACE REPAIRS

- A. Defective Concrete:
 1. Repair and patch defective areas when approved by Architect.
 2. Remove and replace concrete that cannot be repaired and patched to meet specification requirements.
- B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 sieve, using only enough water for handling and placing.
- C. Repairing Unformed Surfaces:
 1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.
 - a. Correct low and high areas.
 - b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.
 2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width.
 3. After concrete has cured at least 14 days, correct high areas by grinding.
 4. Correct localized low areas during, or immediately after, completing surface-finishing operations by adding patching mortar.
 - a. Finish repaired areas to blend into adjacent concrete.
 5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.
 - a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 - b. Feather edges to match adjacent floor elevations.

6. Correct other low areas scheduled to remain exposed with repair topping.
 - a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch to match adjacent floor elevations.
 - b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
 7. Repair defective areas, except random cracks and single holes 1 inch or less in diameter, by cutting out and replacing with fresh concrete.
 - a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch clearance all around.
 - b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
 - c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
 - d. Place, compact, and finish to blend with adjacent finished concrete.
 - e. Cure in same manner as adjacent concrete.
 8. Repair random cracks and single holes 1 inch or less in diameter with patching mortar.
 - a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
 - b. Dampen cleaned concrete surfaces and apply bonding agent.
 - c. Place patching mortar before bonding agent has dried.
 - d. Compact patching mortar and finish to match adjacent concrete.
 - e. Keep patched area continuously moist for at least 72 hours.
- D. Repair materials and installation not specified above may be used, subject to Architect's approval.

3.14 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a special inspector, if required, and qualified testing and inspecting agency to perform field tests and inspections and prepare test reports. Refer to Statement of Special Inspections in Section 01 4533.
- B. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.
 1. Testing agency to be responsible for providing curing facility for initial curing of strength test specimens on-site and verifying that test specimens are cured in accordance with standard curing requirements in ASTM C31/C31M.
 2. Testing agency to immediately report to Architect, Contractor, and concrete manufacturer any failure of Work to comply with Contract Documents.
 3. Testing agency to report results of tests and inspections, in writing, to Owner, Architect, Contractor, and concrete manufacturer within 48 hours of inspections and tests.
 - a. Test reports to include reporting requirements of ASTM C31/C31M, ASTM C39/C39M, and ACI 301, including the following as applicable to each test and inspection:
 - 1) Project name.
 - 2) Name of testing agency.

- 3) Names and certification numbers of field and laboratory technicians performing inspections and testing.
 - 4) Name of concrete manufacturer.
 - 5) Date and time of inspection, sampling, and field testing.
 - 6) Date and time of concrete placement.
 - 7) Location in Work of concrete represented by samples.
 - 8) Date and time sample was obtained.
 - 9) Truck and batch ticket numbers.
 - 10) Design compressive strength at 28 days.
 - 11) Concrete mixture designation, proportions, and materials.
 - 12) Field test results of fresh concrete, including slump or slump flow, air content, temperature and density.
 - 13) Information on storage and curing of samples at the Project site, including curing method and maximum and minimum temperatures during initial curing period.
 - 14) Type of fracture and compressive break strengths at seven days and 28 days.
4. Provide a space and source of power or other resources for curing and access to test specimens by the testing agency.
- C. Delivery Tickets: comply with ASTM C94/C94M.
- D. Inspections:
1. Headed bolts and studs.
 2. Verification of use of required design mixture.
 3. Concrete placement, including conveying and depositing.
 4. Curing procedures and maintenance of curing temperature.
 5. Verification of concrete strength before removal of shores and forms from beams and slabs.
 6. Batch Plant Inspections: On a random basis, as determined by Architect.
- E. Concrete Tests: Testing of composite samples of fresh concrete obtained in accordance with ASTM C 172/C 172M to be performed in accordance with the following requirements:
1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 150 cu. yd. or fraction thereof.
 - a. When frequency of testing provides fewer than five compressive-strength tests for each concrete mixture, testing is to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M:
 - a. One test at point of delivery for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - b. Perform additional tests as needed.
 3. Air Content: ASTM C231/C231M pressure method, for normal-weight concrete;
 - a. One test for each composite sample when strength test specimens are cast, but not less than one test for each day's pour of each concrete mixture.

4. Concrete Temperature: ASTM C1064/C1064M:
 - a. One test hourly when air temperature is 40 deg F and below or 80 deg F and above, and one test for each composite sample when strength test specimens are cast.
 5. Concrete Density: ASTM C138/C138M:
 - a. One test for each composite sample when strength test specimens are cast.
 6. Compression Test Specimens: ASTM C31/C31M:
 - a. Cast and standard cure two sets of three 6 inches by 12-inches or 4-inch by 8-inch cylindrical specimens for each composite sample.
 7. Compressive-Strength Tests: ASTM C39/C39M.
 - a. Test one set of three standard cured specimens at seven days and one set of two specimens at 28 days.
 - b. A compressive-strength test to be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
 8. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests of standard cured cylinders equals or exceeds specified compressive strength, and no compressive-strength test value falls below specified compressive strength by more than 500 psi if specified compressive strength is 5000 psi, or no compressive strength test value is less than 10 percent of specified compressive strength if specified compressive strength is greater than 5000 psi.
 9. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
 10. Additional Tests:
 - a. Testing and inspecting agency to make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
 - b. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/C42M or by other methods as directed by Architect.
 - 1) Acceptance criteria for concrete strength to be in accordance with ACI 301, Section 1.7.6.3.
 11. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 12. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- F. Measure floor and slab flatness and levelness in accordance with ASTM E1155 within 48 hours of completion of floor finishing and promptly report test results to Architect.

3.15 PROTECTION

- A. Protect concrete surfaces as follows:
1. Protect from petroleum stains.
 2. Diaper hydraulic equipment used over concrete surfaces.
 3. Prohibit vehicles from interior concrete slabs.
 4. Prohibit use of pipe-cutting machinery over concrete surfaces.

5. Prohibit placement of steel items on concrete surfaces.
6. Prohibit use of acids or acidic detergents over concrete surfaces.

END OF SECTION 03 3000

SECTION 05 4000 - COLD-FORMED METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cold-formed steel framing.
 - 2. Load-bearing wall framing.
 - 3. Interior non-load-bearing wall framing.
 - 4. Vertical deflection clips, interior.
 - 5. Joist and bulkhead framing.
- B. Related Requirements:
 - 1. Section 05 5000 "Metal Fabrications" for miscellaneous steel shapes, masonry shelf angles, and connections used with cold-formed metal framing.
 - 2. Section 09 2216 "Non-Structural Metal Framing" for standard, interior non-load-bearing, metal-stud framing, within height limitations and ceiling-suspension assemblies.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Shop Drawings:
 - 1. Include layout, spacings, sizes, thicknesses, and types of cold-formed steel framing; fabrication; and fastening and anchorage details, including mechanical fasteners.
 - 2. Indicate reinforcing channels, opening framing, supplemental framing, strapping, bracing, bridging, splices, accessories, connection details, and attachment to adjoining work.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Product Certificates: For each type of code-compliance certification for studs and track.

1.4 QUALITY ASSURANCE

- A. Code-Compliance Certification of Studs and Track: Provide documentation that framing members are certified in accordance with the product-certification program of the Steel Framing Industry Association, The Steel Stud Manufacturers Association or the Supreme Steel Framing System Association.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect and store cold-formed steel framing from corrosion, moisture staining, deformation, and other damage during delivery, storage, and handling as required in AISI S202.

PART 2 - PRODUCTS**2.1 COLD-FORMED STEEL FRAMING**

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ClarkDietrich
 - 2. Marino\WARE
 - 3. SCAFCO Steel Stud Company; Stone Group of Companies
- B. Framing Members, General: Comply with AISI S200 and ASTM C955, Section 8 for conditions indicated.
- C. Steel Sheet: ASTM A1003/A1003M, Structural Grade, Type H, metallic coated, of grade and coating designation as follows:
 - 1. Grade: ST33H.
 - 2. Coating: G60, A60, AZ50, or GF30.
- D. Steel Sheet for Vertical Deflection Drift Clips: ASTM A653/A653M, structural steel, zinc coated, of grade and coating as follows:
 - 1. Grade: As required by structural performance.
 - 2. Coating: G90.

2.2 LOAD-BEARING WALL FRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges.
- B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with straight flanges.
- C. Steel Box or Back-to-Back Headers: Manufacturer's standard C-shapes used to form header beams, of web depths indicated, unpunched, with stiffened flanges.

2.3 INTERIOR NON-LOAD-BEARING WALL FRAMING

- A. Steel Studs: Manufacturer's standard C-shaped steel studs, of web depths indicated, punched, with stiffened flanges.
- B. Steel Track: Manufacturer's standard U-shaped steel track, of web depths indicated, unpunched, with unstiffened flanges, and as follows:
 - 1. Minimum Base-Steel Thickness: Matching steel studs.
 - 2. Flange Width: 1-1/2 inches.

- C. Vertical Deflection Clips, Interior: Manufacturer's standard head clips, capable of accommodating upward and downward vertical displacement of primary structure through positive mechanical attachment to stud web.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich
 - b. Marino\WARE
 - c. SCAFCO Steel Stud Company; Stone Group of Companies
 - d. Simpson Strong-Tie Co., Inc.
- D. Single Deflection Track: Manufacturer's single, deep-leg, U-shaped steel track; unpunched, with unstiffened flanges, of web depth to contain studs while allowing free vertical movement, with flanges designed to support horizontal loads and transfer them to the primary structure.

2.4 JOIST FRAMING

- A. Steel Joists: Manufacturer's standard C-shaped steel joists, of web depths indicated, unpunched with stiffened flanges.
- B. Steel Rim Joist Track: Manufacturer's standard U-shaped steel rim joist track, of web depths indicated, unpunched or punched at joist spacing, with unstiffened flanges.

2.5 FRAMING ACCESSORIES

- A. Fabricate steel-framing accessories from ASTM A1003/A1003M, Structural Grade, Type H, metallic-coated steel sheet, of same grade and coating designation used for framing members.
- B. Provide accessories of manufacturer's standard thickness and configuration, unless otherwise indicated, as follows:
 - 1. Supplementary framing.
 - 2. Bracing, bridging, and solid blocking.
 - 3. Web stiffeners.
 - 4. Anchor clips.
 - 5. End clips.
 - 6. Foundation clips.
 - 7. Stud kickers and knee braces.
 - 8. Joist hangers and end closures.
 - 9. Hole-reinforcing plates.
 - 10. Backer plates.

2.6 ANCHORS, CLIPS, AND FASTENERS

- A. Steel Shapes and Clips: ASTM A36/A36M, zinc coated by hot-dip process in accordance with ASTM A123/A123M.

- B. Post-Installed Anchors: Fastener systems with bolts of same basic metal as fastened metal, if visible, unless otherwise indicated; with working capacity greater than or equal to the design load, in accordance with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01, ICC-ES AC193, ICC-ES AC58, or ICC-ES AC308 as appropriate for the substrate.
 - 1. Uses: Securing cold-formed steel framing to structure.
 - 2. Type: Torque-controlled adhesive anchor or adhesive anchor.
 - 3. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/ASTM F1941M, Class Fe/Zn 5, unless otherwise indicated.
- C. Power-Actuated Anchors: Fastener systems with working capacity greater than or equal to the design load, in accordance with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- D. Mechanical Fasteners: ASTM C1513, corrosion-resistant-coated, self-drilling, self-tapping, steel drill screws.
 - 1. Head Type: Low-profile head beneath sheathing; manufacturer's standard elsewhere.

2.7 MISCELLANEOUS MATERIALS

- A. Galvanizing Repair Paint: ASTM A780/A780M, MIL-P-21035B or SSPC-Paint 20.
- B. Cement Grout: Portland cement, ASTM C476, Type I; and clean, natural sand, ASTM C404. Mix at ratio of 1 part cement to 2-1/2 parts sand, by volume, with minimum water required for placement and hydration.
- C. Nonmetallic, Nonshrink Grout: Factory-packaged, nonmetallic, noncorrosive, nonstaining grout, complying with ASTM C1107/C1107M, and with a fluid consistency and 30-minute working time.
- D. Shims: Load-bearing, high-density, multimonomer, nonleaching plastic; or cold-formed steel of same grade and metallic coating as framing members supported by shims.
- E. Sill Sealer Gasket: Closed-cell neoprene foam, 1/4 inch thick, selected from manufacturer's standard widths to match width of bottom track or rim track members as required.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard Products, Inc.
 - 2. Physical Properties:
 - a. Peel Adhesion: 17.0 lb/in of width when tested in accordance with ASTM D412.
 - b. Low-Temperature Flexibility: Pass at minus 25 deg F when tested in accordance with ASTM D146/D146M.
 - c. Water Vapor Permeance: 0.05 perm maximum when tested in accordance with ASTM E96/E96M, Method B.

- d. Resistance to Termite Penetration: Comply with ICC-ES AC380.

2.8 FABRICATION

- A. Fabricate cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened, in accordance with AISI S240 and standards, manufacturer's written instructions, and requirements in this Section.
1. Fabricate framing assemblies using jigs or templates.
 2. Cut framing members by sawing or shearing; do not torch cut.
 3. Fasten cold-formed steel framing members by screw fastening, clinch fastening, pneumatic pin fastening, or riveting as standard with fabricator. Wire tying of framing members is not permitted.
 - a. Locate mechanical fasteners and install in accordance with Shop Drawings, with screws penetrating joined members by no fewer than three exposed screw threads.
 4. Fasten other materials to cold-formed steel framing by bolting, pneumatic pin fastening, or screw fastening, in accordance with Shop Drawings.
- B. Reinforce, stiffen, and brace framing assemblies to withstand handling, delivery, and erection stresses. Lift fabricated assemblies by means that prevent damage or permanent distortion.
- C. Tolerances: Fabricate assemblies level, plumb, and true to line to a maximum allowable variation of 1/8 inch in 10 ft. and as follows:
1. Spacing: Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative errors are not to exceed minimum fastening requirements of sheathing or other finishing materials.
 2. Squareness: Fabricate each cold-formed steel framing assembly to a maximum out-of-square tolerance of 1/8 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, conditions, and abutting structural framing for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Install load-bearing shims or grout between the underside of load-bearing wall bottom track and the top of foundation wall or slab at locations with a gap larger than 1/4 inch to ensure a uniform bearing surface on supporting concrete or masonry construction.
- B. Install sill sealer gasket at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.

3.3 INSTALLATION OF COLD-FORMED STEEL FRAMING

- A. Cold-formed steel framing may be shop or field fabricated for installation, or it may be field assembled.
- B. Install cold-formed steel framing in accordance with ASTM C1007, AISI S202, and manufacturer's written instructions unless more stringent requirements are indicated.
- C. Install shop- or field-fabricated, cold-formed framing and securely anchor to supporting structure.
 - 1. Screw or bolt wall panels at horizontal and vertical junctures to produce flush, even, true-to-line joints with maximum variation in plane and true position between fabricated panels not exceeding 1/16 inch.
- D. Install cold-formed steel framing and accessories plumb, square, and true to line, and with connections securely fastened.
 - 1. Cut framing members by sawing or shearing; do not torch cut.
 - 2. Fasten cold-formed steel framing members by screw fastening, clinch fastening, or riveting. Wire tying of framing members is not permitted.
 - a. Locate mechanical fasteners, install in accordance with Shop Drawings, and comply with requirements for spacing, edge distances, and screw penetration.
- E. Install framing members in one-piece lengths unless splice connections are indicated for track or tension members.
- F. Install temporary bracing and supports to secure framing and support loads equal to those for which structure was designed. Maintain braces and supports in place, undisturbed, until entire integrated supporting structure has been completed and permanent connections to framing are secured.
- G. Do not bridge building expansion joints with cold-formed steel framing. Independently frame both sides of joints.
- H. Fasten hole-reinforcing plate over web penetrations that exceed size of manufacturer's approved or standard punched openings.

3.4 INSTALLATION OF LOAD-BEARING WALL FRAMING

- A. Install continuous top and bottom track sized to match studs. Align track accurately and securely anchor at corners and ends, and at spacings as follows:
 - 1. Anchor Spacing: As shown on Shop Drawings.
- B. Squarely seat studs against top and bottom track, with gap not exceeding 1/8 inch between the end of wall-framing member and the web of track.
 - 1. Fasten both flanges of studs to top and bottom track.
 - 2. Space studs as follows:
 - a. Stud Spacing: As indicated on Shop Drawings.

- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar configurations.
- D. Align studs vertically where floor framing interrupts wall-framing continuity. Where studs cannot be aligned, continuously reinforce track to transfer loads.
- E. Align floor and roof framing over studs in accordance with AISI S240, Section C3.5.2. Where framing cannot be aligned, continuously reinforce track to transfer loads.
- F. Anchor studs abutting structural columns or walls, including masonry walls, to supporting structure.
- G. Install headers over wall openings wider than stud spacing. Locate headers above openings. Fabricate headers of compound shapes indicated or required to transfer load to supporting studs, complete with clip-angle connectors, web stiffeners, or gusset plates.
 - 1. Frame wall openings with not less than a double stud at each jamb of frame as indicated on Shop Drawings. Fasten jamb members together to uniformly distribute loads.
 - 2. Install track and jack studs above and below wall openings. Anchor track to jamb studs with clip angles and space jack studs same as full-height wall studs.
- H. Install supplementary framing, blocking, and bracing in stud framing indicated to support fixtures, equipment, services, casework, heavy trim, furnishings, and similar work requiring attachment to framing.
 - 1. If type of supplementary support is not indicated, comply with stud manufacturer's written recommendations and industry standards in each case, considering weight or load resulting from item supported.
- I. Install horizontal bridging in stud system, spaced vertically 48 inches. Fasten at each stud intersection.
 - 1. Channel Bridging: Cold-rolled steel channel, mechanically fastened to webs of punched studs with a minimum of two screws into each flange of the clip angle for framing members up to 6 inches deep.
 - 2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges, and secure solid blocking to stud webs or flanges.
 - 3. Bar Bridging: Proprietary bridging bars installed in accordance with manufacturer's written instructions.
- J. Install steel sheet diagonal bracing straps to both stud flanges; terminate at and fasten to reinforced top and bottom track. Fasten clip-angle connectors to multiple studs at ends of bracing and anchor to structure.
- K. Install miscellaneous framing and connections, including supplementary framing, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.5 INSTALLATION OF INTERIOR NON-LOAD-BEARING WALL FRAMING

- A. Install continuous track sized to match studs. Align track accurately and securely anchor to supporting structure.
- B. Fasten both flanges of studs to top and bottom track unless otherwise indicated. Space studs as follows:
 - 1. Stud Spacing: As indicated on Drawings.
- C. Set studs plumb, except as needed for diagonal bracing or required for nonplumb walls or warped surfaces and similar requirements.
- D. Isolate non-load-bearing steel framing from building structure to prevent transfer of vertical loads while providing lateral support.
 - 1. Install single deep-leg deflection track and anchor to building structure.
 - 2. Connect vertical deflection clips to studs and anchor to building structure.
- E. Install horizontal bridging in wall studs, spaced vertically in rows indicated on Shop Drawings but not more than 48 inches apart. Fasten at each stud intersection.
 - 1. Channel Bridging: Cold-rolled steel channel, mechanically fastened to webs of punched studs.
 - 2. Strap Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and stud-track solid blocking of width and thickness to match studs. Fasten flat straps to stud flanges and secure solid blocking to stud webs or flanges.
 - 3. Bar Bridging: Proprietary bridging bars installed according to manufacturer's written instructions.
- F. Top Bridging for Single Deflection Track: Install row of horizontal bridging within 18 inches of single deflection track. Install a combination of bridging and stud or stud-track solid blocking of width and thickness matching studs, secured to stud webs or flanges.
 - 1. Install solid blocking at 96-inch centers.
- G. Install miscellaneous framing and connections, including stud kickers, web stiffeners, clip angles, continuous angles, anchors, and fasteners, to provide a complete and stable wall-framing system.

3.6 INSTALLATION OF JOIST FRAMING

- A. Install perimeter joist track sized to match joists. Align and securely anchor or fasten track to supporting structure at corners, ends, and spacings indicated on Shop Drawings.
- B. Install joists bearing on supporting frame, level, straight, and plumb; adjust to final position, brace, and reinforce. Fasten joists to both flanges of joist track.
 - 1. Install joists over supporting frame with a minimum end bearing as indicated on Shop Drawings.
 - 2. Reinforce ends and bearing points of joists with web stiffeners, end clips, joist hangers, steel clip angles, or steel-stud sections.

- C. Space joists not more than 2 inches from abutting walls, and as follows:
 - 1. Joist Spacing: As indicated on Drawings.
- D. Frame openings with built-up joist headers, consisting of joist and joist track or another combination of connected joists if indicated.
- E. Install joist reinforcement at interior supports with single, short length of joist section located directly over interior support, with lapped joists of equal length to joist reinforcement.
 - 1. Install web stiffeners to transfer axial loads of walls above.
- F. Install bridging at intervals indicated on Shop Drawings. Fasten bridging at each joist intersection as follows:
 - 1. Joist-Track Solid Bridging: Joist-track solid blocking of width and thickness indicated, secured to joist webs.
 - 2. Combination Bridging: Combination of flat, taut, steel sheet straps of width and thickness indicated and joist-track solid blocking of width and thickness indicated. Fasten flat straps to bottom flange of joists and secure solid blocking to joist webs.
- G. Secure joists to load-bearing interior walls to prevent lateral movement of bottom flange.
- H. Install miscellaneous joist framing and connections, including web stiffeners, closure pieces, clip angles, continuous angles, hold-down angles, anchors, and fasteners, to provide a complete and stable joist-framing assembly.

3.7 INSTALLATION TOLERANCES

- A. Install cold-formed steel framing level, plumb, and true to line to a maximum allowable tolerance variation of 1/8 inch in 10 ft. and as follows:
 - 1. Space individual framing members no more than plus or minus 1/8 inch from plan location. Cumulative error are not to exceed minimum fastening requirements of sheathing or other finishing materials.

3.8 REPAIR

- A. Galvanizing Repairs: Prepare and repair damaged galvanized coatings on fabricated and installed cold-formed steel framing with galvanized repair paint in accordance with ASTM A780/A780M and manufacturer's written instructions.

3.9 FIELD QUALITY CONTROL

- A. Testing: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- B. Testing agency will report test results promptly and in writing to Contractor and Architect.

- C. Cold-formed steel framing will be considered defective if it does not pass tests and inspections.
- D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.10 PROTECTION

- A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that cold-formed steel framing is without damage or deterioration at time of Substantial Completion.

END OF SECTION 05 4000

SECTION 05 5000 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Miscellaneous framing and supports.
 - 2. Loose steel lintels.
 - 3. Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.
 - 4. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.

1.2 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Fasteners.
 - 2. Shop primers.
 - 3. Shrinkage-resisting grout.
 - 4. Slotted channel framing.
- B. Shop Drawings: Show fabrication and installation details. Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items. Provide Shop Drawings for the following:
 - 1. Miscellaneous framing and supports for applications where framing and supports are not specified in other Sections.
 - 2. Loose steel lintels.

1.4 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls, floor slabs, decks, and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 METALS

- A. Metal Surfaces, General: Provide materials with smooth, flat surfaces unless otherwise indicated. For metal fabrications exposed to view in the completed Work, provide materials without seam marks, roller marks, rolled trade names, or blemishes.
- B. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
- C. Stainless Steel Sheet, Strip, and Plate: ASTM A240/A240M or ASTM A666, Type 304.
- D. Stainless Steel Bars and Shapes: ASTM A276/A276M, Type 304.
- E. Steel Tubing: ASTM A500/A500M, cold-formed steel tubing.
- F. Steel Pipe: ASTM A53/A53M, Standard Weight (Schedule 40) unless otherwise indicated.
- G. Slotted Channel Framing: Cold-formed metal box channels (struts) complying with MFMA-4.
 - 1. Size of Channels: 1-5/8 by 1-5/8 inches.
 - 2. Galvanized Steel: ASTM A653/A653M, commercial steel, Type B, with G90 coating; 0.079-inch nominal thickness.
 - 3. Cold-Rolled Steel: ASTM A1008/A1008M, structural steel, Grade 33; 0.0677-inch minimum thickness; coated with rust-inhibitive, baked-on, acrylic enamel.
- H. Aluminum Plate and Sheet: ASTM B209, Alloy 6061-T6.
- I. Aluminum Extrusions: ASTM B221, Alloy 6063-T6.

2.2 FASTENERS

- A. General: Unless otherwise indicated, provide Type 304 stainless steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
 - 1. Provide stainless steel fasteners for fastening aluminum stainless steel or nickel silver.
 - 2. Provide bronze fasteners for fastening bronze.
- B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A; with hex nuts, ASTM A563; and, where indicated, flat washers.
- C. High-Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325, Type 3, heavy-hex steel structural bolts; ASTM A563, Grade DH3, heavy-hex carbon-steel nuts; and where indicated, flat washers.

- D. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563; and, where indicated, flat washers.
 - 1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.
- E. Anchors, General: Capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing in accordance with ASTM E488/E488M, conducted by a qualified independent testing agency.
- F. Cast-in-Place Anchors in Concrete: Either threaded or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329/F2329M.
- G. Post-Installed Anchors: Torque-controlled expansion anchors or chemical anchors.
 - 1. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 - 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 stainless steel bolts, ASTM F593, and nuts, ASTM F594.
- H. Slotted-Channel Inserts: Cold-formed, hot-dip galvanized-steel box channels (struts) complying with MFMA-4, 1-5/8 by 7/8 inches by length indicated with anchor straps or studs not less than 3 inches long at not more than 8 inches o.c. Provide with temporary filler and tee-head bolts, complete with washers and nuts, all zinc-plated to comply with ASTM B633, Class Fe/Zn 5, as needed for fastening to inserts.

2.3 MISCELLANEOUS MATERIALS

- A. Shop Primers: Provide primers that comply with Section 09 9124 "Interior Painting (MPI Standards)."
- B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- C. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- D. Shrinkage-Resistant Grout: Factory-packaged, nonmetallic, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.
- E. Concrete: Comply with requirements in Section 03 3000 "Cast-in-Place Concrete" for normal-weight, air-entrained concrete with a minimum 28-day compressive strength of 3000 psi.

2.4 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.
- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.

2.5 MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Provide steel framing and supports not specified in other Sections as needed to complete the Work.
- B. Fabricate units from steel shapes, plates, and bars of welded construction unless otherwise indicated. Fabricate to sizes, shapes, and profiles indicated and as necessary to receive adjacent construction.
 - 1. Fabricate units from slotted channel framing where indicated.
 - 2. Furnish inserts for units installed after concrete is placed.

- C. Galvanize miscellaneous framing and supports where indicated.
- D. Prime miscellaneous framing and supports with primer specified in Section 09 9124 "Interior Painting (MPI Standards)" where indicated.

2.6 LOOSE STEEL LINTELS

- A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.
- B. Size loose lintels to provide bearing length at each side of openings equal to one-twelfth of clear span, but not less than 8 inches unless otherwise indicated.
- C. Galvanize loose steel lintels located in exterior walls.

2.7 STEEL WELD PLATES AND ANGLES

- A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.8 GENERAL FINISH REQUIREMENTS

- A. Finish metal fabrications after assembly.
- B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.9 STEEL AND IRON FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
- B. Shop prime iron and steel items not indicated to be galvanized unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
 - 1. Shop prime with unless primers specified in Section 09 9124 "Interior Painting (MPI Standards)" are indicated.
- C. Preparation for Shop Priming: Prepare surfaces to comply with requirements indicated below:
 - 1. Exterior Items: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 - 2. Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

3. Items Indicated to Receive Primers Specified in Section 09 9124 "Interior Painting (MPI Standards)": SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
 4. Other Steel Items: SSPC-SP 3, "Power Tool Cleaning."
 5. Galvanized-Steel Items: SSPC-SP 16, "Brush-off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals."
- D. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

2.10 ALUMINUM FINISHES

- A. As-Fabricated Finish: AA-M12.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.
- C. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
1. Cast Aluminum: Heavy coat of bituminous paint.
 2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLATION OF MISCELLANEOUS FRAMING AND SUPPORTS

- A. General: Install framing and supports to comply with requirements of items being supported, including manufacturers' written instructions and requirements indicated on Shop Drawings.
- B. Anchor supports for ceiling-hung toilet partitions securely to, and rigidly brace from, building structure.
- C. Support steel girders on solid grouted masonry, concrete, or steel pipe columns. Secure girders with anchor bolts embedded in grouted masonry or concrete or with bolts through top plates of pipe columns.
 - 1. Where grout space under bearing plates is indicated for girders supported on concrete or masonry, install as specified in "Installing Bearing and Leveling Plates" Article.

3.3 REPAIRS

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil dry film thickness.
 - 2. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09 9124 "Interior Painting (MPI Standards)."
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION 05 5000

SECTION 06 1000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
1. Wood products.
 2. Fire-retardant-treated lumber.
 3. Miscellaneous lumber.
 4. Plywood backing panels.

1.2 DEFINITIONS

- A. Boards or Strips: Lumber of less than 2 inches nominal size in least dimension.
- B. Dimension Lumber: Lumber of 2 inches nominal size or greater but less than 5 inches nominal size in least dimension.
- C. Exposed Framing: Framing not concealed by other construction.
- D. Lumber grading agencies, and abbreviations used to reference them, include the following:
1. NeLMA: Northeastern Lumber Manufacturers' Association.
 2. NLGA: National Lumber Grades Authority.
 3. SPIB: The Southern Pine Inspection Bureau.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.
 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 3. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5664.
 4. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Stack wood products flat with spacers beneath and between each bundle to provide air circulation. Protect wood products from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS

- A. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - 1. Factory mark each piece of lumber with grade stamp of grading agency.
 - 2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
 - 3. Dress lumber, S4S, unless otherwise indicated.
- B. Maximum Moisture Content:
 - 1. Boards: 15 percent.

2.2 FIRE-RETARDANT-TREATED LUMBER

- A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet beyond the centerline of the burners at any time during the test.
 - 1. Treatment is not to promote corrosion of metal fasteners.
 - 2. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested in accordance with ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.
 - 3. Design Value Adjustment Factors: Treated lumber is to be tested according to ASTM D5664 and design value adjustment factors are to be calculated according to ASTM D6841.
- C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent. Kiln-dry plywood after treatment to maximum moisture content of 15 percent.
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency and other information required by authorities having jurisdiction.

- E. For exposed items indicated to receive a stained or natural finish, chemical formulations are not to bleed through, contain colorants, or otherwise adversely affect finishes.
- F. Application: Treat items indicated on Drawings, and the following:
 - 1. Concealed blocking.
 - 2. Plywood backing panels.

2.3 MISCELLANEOUS LUMBER

- A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of any of the following species:
 - 1. Mixed southern pine or southern pine; SPIB.
 - 2. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
- C. Concealed Boards: 19 percent maximum moisture content and any of the following species and grades:
 - 1. Mixed southern pine or southern pine; No. 2 grade; SPIB.
 - 2. Spruce-pine-fir (south) or spruce-pine-fir; Construction or No. 2 Common grade; NeLMA, NLGA, WCLIB, or WWPA.
- D. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.
- E. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.4 PLYWOOD BACKING PANELS

- A. Equipment Backing Panels: Plywood, DOC PS 1, Exterior, A-C, fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch nominal thickness.

2.5 FASTENERS

- A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches into wood substrate.
 - 1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with ASTM F2329 of Type 304 stainless steel.
- B. Nails, Brads, and Staples: ASTM F1667.
- C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

PART 3 - EXECUTION**3.1 INSTALLATION**

- A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.
- B. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels.
- C. Install metal framing anchors to comply with manufacturer's written instructions. Install fasteners through each fastener hole.
- D. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- E. Comply with AWPAC M4 for applying field treatment to cut surfaces of preservative-treated lumber.
 - 1. Use inorganic boron for items that are continuously protected from liquid water.
 - 2. Use copper naphthenate for items not continuously protected from liquid water.
- F. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- G. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in ICC's International Building Code (IBC).
 - 2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
 - 3. ICC-ES evaluation report for fastener.
- H. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 INSTALLATION OF WOOD BLOCKING AND NAILERS

- A. Install where indicated and where required for attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

- B. Attach wood blocking to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.

3.3 PROTECTION

- A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 06 1000

SECTION 06 4023 - INTERIOR ARCHITECTURAL WOODWORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior wood bench
 - 2. Miscellaneous materials.

1.2 COORDINATION

- A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections, to ensure that interior architectural woodwork can be supported and installed as indicated.

1.3 ACTION SUBMITTALS

- A. Shop Drawings:
 - 1. Include the following:
 - a. Dimensioned plans, elevations, and sections.
 - b. Attachment details.
 - 2. Show large-scale details.
 - 3. Show locations and sizes of furring, blocking, and hanging strips, including blocking and reinforcement concealed by construction and specified in other Sections.
 - 4. Apply AWI Quality Certification Program label to Shop Drawings.

1.4 CLOSEOUT SUBMITTALS

- A. Quality Standard Compliance Certificates: AWI Quality Certification Program certificates.

1.5 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.
 - 1. Manufacturer's Certification: Licensed participant in AWI's Quality Certification Program.
 - 2. Installer Qualifications: Manufacturer of products and Licensed participant in AWI's Quality Certification Program.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Comply with the Architectural Woodwork Standards, Section 2.
- B. Do not deliver interior architectural woodwork until painting and similar finish operations that might damage woodwork have been completed in installation areas.

- C. Store woodwork in installation areas or in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.
 - 1. Handle and store fire-retardant-treated wood to comply with chemical treatment manufacturer's written instructions.

1.7 FIELD CONDITIONS

- A. Environmental Limitations without Humidity Control: Do not deliver or install interior architectural woodwork until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels designed for building occupants for the remainder of the construction period.
- B. Environmental Limitations with Humidity Control: Do not deliver or install interior architectural woodwork until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F and relative humidity between 25 and 55 percent during the remainder of the construction period.
- C. Field Measurements: Where interior architectural woodwork is indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings.
 - 1. Locate concealed framing, blocking, and reinforcements that support woodwork by field measurements before being concealed by construction, and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 WOODWORK, GENERAL

- A. Quality Standard: Unless otherwise indicated, comply with the Architectural Woodwork Standards for grades of interior architectural woodwork indicated for construction, finishes, installation, and other requirements.
 - 1. Provide labels from AWI certification program indicating that woodwork complies with requirements of grades specified.

2.2 INTERIOR WOOD BENCH

- A. Architectural Woodwork Standards Grade: Premium.
- B. Wood for Transparent Finish:
 - 1. Species and Cut:
 - a. Bench surface: Oak veneer
 - b. Bench edge: Hardwood oak
 - 2. Wood Moisture Content: 5 to 10 percent.

2.3 MISCELLANEOUS MATERIALS

- A. Furring, Blocking, Shims, and Nailers: Softwood or hardwood lumber, kiln-dried to less than 15 percent moisture content.

- B. Provide self-drilling screws for metal-framing supports, as recommended by metal-framing manufacturer.
- C. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage.
 - 1. Provide metal expansion sleeves or expansion bolts for post-installed anchors.
 - 2. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.
- D. Installation Adhesive: Product recommended by fabricator for each substrate for secure anchorage.

2.4 FABRICATION

- A. Fabricate interior architectural woodwork to dimensions, profiles, and details indicated.
 - 1. Ease edges to radius indicated for the following:
 - a. Edges of Solid-Wood (Lumber) Members: 1/16 inch unless otherwise indicated.
- B. Complete fabrication, including assembly, to maximum extent possible before shipment to Project site.
 - 1. Disassemble components only as necessary for shipment and installation.
 - 2. Where necessary for fitting at site, provide allowance for scribing, trimming, and fitting.
 - 3. Trial fit assemblies at fabrication shop that cannot be shipped completely assembled.
 - a. Install dowels, screws, bolted connectors, and other fastening devices that can be removed after trial fitting.
 - b. Verify that parts fit as intended, and check measurements of assemblies against field measurements indicated on approved Shop Drawings before disassembling for shipment.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before installation, condition interior architectural woodwork to humidity conditions in installation areas for not less than 72 hours prior to beginning of installation.
- B. Before installing interior architectural woodwork, examine shop-fabricated work for completion and complete work as required, including removal of packing and backpriming of concealed surfaces.

3.2 INSTALLATION

- A. Grade: Install interior architectural woodwork to comply with same grade as item to be installed.
- B. Assemble interior architectural woodwork and complete fabrication at Project site to the extent that it was not completed during shop fabrication.

- C. Install interior architectural woodwork level, plumb, true in line, and without distortion.
 - 1. Shim as required with concealed shims.
 - 2. Install level and plumb to a tolerance of 1/8 inch in 96 inches.
- D. Scribe and cut interior architectural woodwork to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
- E. Anchor interior architectural woodwork to anchors or blocking built in or directly attached to substrates.
 - 1. Secure with countersunk, concealed fasteners and blind nailing.
 - 2. Use fine finishing nails for exposed fastening, countersunk and filled flush with interior architectural woodwork.
 - 3. For shop-finished items, use filler matching finish of items being installed.
- F. Standing and Running Trim:
 - 1. Install with minimum number of joints possible, using full-length pieces (from maximum length of lumber available) to greatest extent possible.
 - 2. Do not use pieces less than 96 inches long, except where shorter single-length pieces are necessary.
 - 3. Scarf running joints and stagger in adjacent and related members.

3.3 REPAIR

- A. Repair damaged and defective interior architectural woodwork, where possible, to eliminate functional and visual defects and to result in interior architectural woodwork being in compliance with requirements of Architectural Woodwork Standards for the specified grade.
- B. Where not possible to repair, replace defective woodwork.
- C. Field Finish: See Section 09 9301 "Staining and Transparent Finishing (MPI Standards)" for final finishing of installed interior architectural woodwork not indicated to be shop finished.

3.4 CLEANING

- A. Clean interior architectural woodwork on exposed and semiexposed surfaces.

END OF SECTION 06 4023

SECTION 07 8413 - PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Penetration firestopping systems.
 - 1. Penetration firestopping systems in fire-resistance-rated walls.
 - 2. Exposed penetration firestopping systems.
- B. Related Requirements:
 - 1. Section 07 9200 "Joint Sealants" for non-fire-resistance-rated joint sealants.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: For each penetration firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing and inspecting agency.
- C. Unlisted Firestopping Systems: Obtain an Engineering Judgment (EJ) from firestopping manufacturer where no UL, FM Approvals, or other listed assembly is available for particular firestop configuration. Follow International Firestop Council (IFC) recommended guidelines for evaluating firestopping systems in EJs.
 - 1. Engineering Judgments: Where Project conditions require modification to a qualified testing and inspecting agency's illustration for a particular penetration firestopping system, submit illustration, with modifications marked, approved by penetration firestopping system manufacturer's fire-protection engineer as an engineering judgment or equivalent fire-resistance-rated assembly developed in accordance with current International Firestop Council (IFC) recommended guidelines. Obtain approval of authorities having jurisdiction prior to submittal.
- D. Sustainable Design Submittals:

1.3 CLOSEOUT SUBMITTALS

- A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

1.4 FIELD CONDITIONS

- A. Environmental Limitations: Do not install penetration firestopping systems when ambient or substrate temperatures are outside limits permitted by penetration firestopping system manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.

- B. Install and cure penetration firestopping system materials in accordance with manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.5 COORDINATION

- A. Coordinate construction of openings and penetrating items to ensure that penetration firestopping systems can be accessed and installed in accordance with specified firestopping system design.
- B. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate penetration firestopping systems.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain penetration firestopping systems for each type of opening indicated from single manufacturer.

2.2 PENETRATION FIRESTOPPING SYSTEMS

- A. Penetration firestopping systems must be compatible with one another, with the substrates forming openings, and with penetrating items if any.
 - 1. Penetration firestopping systems must be installed with products bearing the classification marking of a qualified testing agency.
 - a. UL Solutions in its online directory "Product iQ."
 - b. Intertek Group in its "Directory of Building Products."
 - c. FM Approvals in its "Approval Guide."
 - 2. Provide components for each penetration firestopping system that, upon curing, do not re-emulsify, dissolve, leach, break down, or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water, or other forms of moisture characteristic during and after construction.
 - 3. Provide components for each penetration firestopping system that do not contain ethylene glycol.
 - 4. Provide components for each penetration firestopping system that are sufficiently flexible to accommodate movement, such as pipe vibration, water hammer, thermal expansion, and other normal building movement without damage.
 - 5. Provide components for each penetration firestopping system that are appropriately tested for the thickness and type of insulation utilized.
- B. Provide penetration firestopping systems that resist spread of fire, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.
- C. Penetration Firestopping Systems in Fire-Resistance-Rated Walls: Systems with ratings determined in accordance with ASTM E814 or UL 1479.
 - 1. F-Rating: Not less than the fire-resistance rating of the wall assembly penetrated.

2. Membrane Penetrations: Install recessed fixtures such that the required fire resistance will not be reduced.
- D. Penetration Firestopping Systems in Horizontal Assemblies: Systems with ratings determined in accordance with ASTM E814 or UL 1479.
 1. F-Rating: At least one hour, but not less than the fire-resistance rating of the floor/ceiling assembly penetrated.
 2. T-Rating: At least one hour, but not less than the fire-resistance rating of the floor/ceiling assembly. The following horizontal penetrations do not require a T-rating:
 - a. Those within the cavity of a wall.
 - b. Floor, tub, or shower drains within a concealed space.
 - c. 4-inch or smaller metal conduit penetrating directly into metal-enclosed electrical switchgear.
- E. Penetration Firestopping Systems in Smoke Barriers: Systems with ratings determined in accordance with UL 1479.
 1. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening and no more than 50-cfm cumulative total for any 100 sq. ft. at both ambient and elevated temperatures.
- F. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested in accordance with ASTM E84 or UL 723.
 1. Product Data: Verify architectural sealant has a VOC content of 250 g/L or less.

2.3 ACCESSORIES

- A. Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated, including but not limited to:
 1. Permanent forming/damming/backing materials.
 2. Substrate primers.
 3. Collars.
 4. Steel sleeves.

2.4 FILL MATERIALS

- A. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.
- B. Firestopping Devices: Factory-assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
- C. Intumescent Composite Sheets: Rigid panels consisting of aluminum-foil-faced intumescent elastomeric sheet bonded to galvanized-steel sheet.
- D. Intumescent Putties: Nonhardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.

- E. Intumescent Wrap Strips: Single-component intumescent elastomeric strips for use around combustible penetrants.
- F. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers and lightweight aggregate formulated for mixing with water at Project site to form a nonshrinking, homogeneous mortar.
- G. Pillows/Bags: Compressible, removable, and reusable intumescent pillows encased in fire-retardant polyester or glass-fiber cloth. Where exposed, and when required by a listed system, cover openings with steel-reinforcing wire mesh to protect pillows/bags from being easily removed or dislodged.
- H. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- I. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants.
- J. Thermal and Endothermic Wraps: Flexible, insulating, and fire-resistant protective wraps tested and listed for up to 2-hour fire ratings in accordance with ASTM E814 or UL 1479; for protecting membrane penetrations of utility boxes, critical electrical circuits, communications lines, and fuel lines, and for thermal barrier and circuit integrity protection in accordance with ASTM E1725 or UL 1724.
- K. Fire-Rated Cable Sleeve Kits: Complete kits designed for new or existing cable penetrations through walls which accept standard accessories.
- L. Fire-Rated Cable Pathways: Single or gangable device modules composed of a steel raceway with integral intumescent material and requiring no additional action in the form of plugs, twisting closure, putty, pillows, sealant, or otherwise to achieve fire and air-leakage ratings.
 - 1. Fire-rated cable pathway devices are the preferred product for data, video, and communications cable penetrations. Install these devices in locations where frequent cable moves, add-ons, and changes will occur. Such devices must be:
 - a. Capable of retrofit around existing cables.
 - b. Designed so that two or more devices can be ganged together.
 - c. Maintenance-free so no action is required to activate the smoke- and fire-sealing mechanism.
 - 2. Where fire-rated cable pathway devices are not practical, openings within walls and floors designed to accommodate data, video, and communications cabling must be provided with re-enterable products specifically designed for retrofit, such as retrofit devices for cable bundles, firestopping putty, plugs, or pillows.
- M. Retrofit Device for Cable Bundles: Factory-made, intumescent, collar-like device for firestopping existing over-filled cable sleeves and capable of being installed around projecting sleeves and cable bundles.
- N. Wall-Opening Protective Materials: Intumescent, non-curing putty pads or self-adhesive inserts for protection of electrical switch and receptacle boxes.

- O. Fire-Rated HVAC Retaining Angles: Steel angle system with integral intumescent firestopping gasket for use around rectangular steel HVAC ducts without fire dampers.
- P. Firestopping Plugs: Flexible, re-enterable, intumescent, foam-rubber plug for use in blank round openings and cable sleeves.
- Q. Fire-Rated Cable Grommet: Molded two-piece grommet made of plenum-grade polymer and foam inner core for sealing small cable penetrations in gypsum walls up to 1/2 inch in diameter.
- R. Closet Flange Gasket: Molded, single-component, flexible, intumescent gasket for use beneath a water closet (toilet) flange in floor applications.

2.5 MIXING

- A. Penetration Firestopping Materials: For those products requiring mixing before application, comply with penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning: Before installing penetration firestopping systems, clean out openings in accordance with manufacturer's written instructions and with the following requirements:
 - 1. Remove foreign materials from substrate surfaces that could interfere with adhesion of penetration firestopping materials.
 - 2. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
 - 3. Remove laitance and form-release agents from concrete.
- B. Prime substrates in accordance with penetration firestopping system manufacturer's written installation instructions, using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

3.3 INSTALLATION OF PENETRATION FIRESTOPPING SYSTEMS

- A. General: Install penetration firestopping systems in accordance with manufacturer's written installation instructions and published drawings for products and applications.
- B. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.
 - 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.
- C. Install fill materials by proven techniques to produce the following results:
 - 1. Fill voids and cavities formed by openings, forming materials, accessories, and penetrating items to achieve required fire-resistance ratings.
 - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 - 3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

3.4 IDENTIFICATION

- A. Wall Identification: Permanently label walls containing penetration firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches high and with minimum 0.375-inch strokes.
 - 1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 ft. from end of wall and at intervals not exceeding 30 ft.
- B. Penetration Identification: Identify each penetration firestopping system with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches of penetration firestopping system edge so labels are visible to anyone seeking to remove penetrating items or firestopping systems. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:
 - 1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
 - 2. Contractor's name, address, and phone number.
 - 3. Designation of applicable testing and inspecting agency.
 - 4. Date of installation.
 - 5. Manufacturer's name.
 - 6. Installer's name.

3.5 FIELD QUALITY CONTROL

- A. Owner will engage a qualified inspection agency to conduct and report on inspections in accordance with ASTM E2174.
- B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.

- C. Proceed with enclosing penetration firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

3.6 CLEANING AND PROTECTION

- A. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.
- B. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

END OF SECTION 07 8413

SECTION 07 9200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Silicone joint sealants.
 - 2. Nonstaining silicone joint sealants.
 - 3. Urethane joint sealants.
 - 4. Mildew-resistant joint sealants.
 - 5. Latex joint sealants.

1.2 ACTION SUBMITTALS

- A. Product Data.
- B. Samples for Initial Selection: Manufacturer's standard color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
- C. Joint-Sealant Schedule.

1.3 CLOSEOUT SUBMITTALS

- A. Manufacturers' special warranties.
- B. Installer's special warranties.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Qualified in accordance with ASTM C1021 to conduct the testing indicated.

1.5 WARRANTY

- A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.
- B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

- C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
 - 1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
 - 2. Disintegration of joint substrates from causes exceeding design specifications.
 - 3. Mechanical damage caused by individuals, tools, or other outside agents.
 - 4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. VOC Content: Verify sealants and sealant primers comply with the following:
 - 1. Architectural sealants have a VOC content of 250 g/L or less.
 - 2. Sealants and sealant primers for nonporous substrates have a VOC content of 250 g/L or less.
 - 3. Sealants and sealant primers for porous substrates have a VOC content of 775 g/L or less.
- C. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 NONSTAINING SILICONE JOINT SEALANTS

- A. Nonstaining Joint Sealants: No staining of substrates when tested in accordance with ASTM C1248.
- B. Silicone, Nonstaining, S, NS, 50, NT: Nonstaining, single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.
 - b. Pecora Corporation
 - c. Sika Corporation - Building Components
 - d. Tremco Incorporated
 - e. Approved Equivalent

2.3 URETHANE JOINT SEALANTS

- A. Urethane, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, urethane joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation
 - b. Polymeric Systems, Inc.; PPG Industries, Inc.
 - c. Sika Corporation; Joint Sealants.
 - d. Tremco Incorporated.
 - e. Approved Equivalent
- B. Urethane, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation
 - b. Polymeric Systems, Inc.; PPG Industries, Inc.
 - c. Approved Equivalent

2.4 MILDEW-RESISTANT JOINT SEALANTS

- A. Mildew-Resistant Joint Sealants: Formulated for prolonged exposure to humidity with fungicide to prevent mold and mildew growth.
- B. Silicone, Mildew Resistant, Acid Curing, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. GE Construction Sealants; Momentive Performance Materials Inc.
 - b. Pecora Corporation
 - c. Tremco Incorporated
 - d. Approved Equivalent

2.5 LATEX JOINT SEALANTS

- A. Acrylic Latex: Acrylic latex or siliconized acrylic latex, ASTM C834, Type OP, Grade NF.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation

- b. Sherwin-Williams Company (The)
- c. Tremco Incorporated

2.6 JOINT-SEALANT BACKING

- A. Sealant Backing Material: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Adfast
 - b. Alcot Plastics Ltd.
 - c. Construction Foam Products; a division of Nomaco, Inc.
 - d. Master Builders Solutions
- B. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin) Type B (bicellular material with a surface skin) or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.7 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. **Surface Cleaning of Joints:** Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - a. Concrete.
 - b. Masonry.
 - c. Unglazed surfaces of ceramic tile.
 3. Remove laitance and form-release agents from concrete.
 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
 - a. Metal.
 - b. Glass.
 - c. Porcelain enamel.
 - d. Glazed surfaces of ceramic tile.
- B. **Joint Priming:** Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. **Masking Tape:** Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF JOINT SEALANTS

- A. **General:** Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. **Sealant Installation Standard:** Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. **Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.**
1. Do not leave gaps between ends of sealant backings.

2. Do not stretch, twist, puncture, or tear sealant backings.
 3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
1. Place sealants so they directly contact and fully wet joint substrates.
 2. Completely fill recesses in each joint configuration.
 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
1. Remove excess sealant from surfaces adjacent to joints.
 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
 3. Provide concave joint profile in accordance with Figure 8A in ASTM C1193 unless otherwise indicated.
 4. Provide flush joint profile at locations indicated on Drawings in accordance with Figure 8B in ASTM C1193.
 5. Provide recessed joint configuration of recess depth and at locations indicated on Drawings in accordance with Figure 8C in ASTM C1193.
 - a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

3.4 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION 07 9200

SECTION 08 1113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior standard steel doors and frames.
- B. Related Requirements:
 - 1. Section 08 7100 "Door Hardware" for door hardware for hollow-metal doors.
 - 2. Section 08 8000 "Glazing".

1.2 DEFINITIONS

- A. Minimum Thickness: Minimum thickness of base metal without coatings in accordance with NAAMM-HMMA 803 or ANSI/SDI A250.8.

1.3 COORDINATION

- A. Coordinate anchorage installation for hollow-metal frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.
- B. Coordinate requirements for installation of door hardware, electrified door hardware, and access control and security systems.

1.4 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Include construction details, material descriptions, core descriptions, fire-resistance ratings, and finishes.
- B. Shop Drawings: Include the following:
 - 1. Elevations of each door type.
 - 2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
 - 3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.
 - 4. Locations of reinforcement and preparations for hardware.
 - 5. Details of each different wall opening condition.
 - 6. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
 - 7. Details of anchorages, joints, field splices, and connections.
 - 8. Details of accessories.
 - 9. Details of moldings, removable stops, and glazing.

- C. Product Schedule: For hollow-metal doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver hollow-metal doors and frames palletized, packaged, or crated to provide protection during transit and Project-site storage. Do not use nonvented plastic.
 - 1. Provide additional protection to prevent damage to factory-finished units.
- B. Deliver welded frames with two removable spreader bars across bottom of frames, tack welded to jambs and mullions.
- C. Store hollow-metal doors and frames vertically under cover at Project site with head up. Place on minimum 4-inch- high wood blocking. Provide minimum 1/4-inch space between each stacked door to permit air circulation.

PART 2 - PRODUCTS

2.1 HOLLOW METAL DOORS AND FRAMES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ceco Door; AADG, Inc.; ASSA ABLOY
 - 2. Curries, AADG, Inc.; ASSA ABLOY Group
 - 3. DE LA FONTAINE
 - 4. Mesker Door; Mesker Openings Group
 - 5. Pioneer Industries; AADG, Inc.; ASSA ABLOY
 - 6. Republic Doors and Frames; an Allegion brand
 - 7. Steelcraft; Allegion plc

2.2 INTERIOR STANDARD STEEL DOORS AND FRAMES

- A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.
- B. Extra-Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 3; ANSI/SDI A250.4, Level A. At locations indicated in the Door and Frame Schedule on Drawings.
 - 1. Doors:
 - a. Type: As indicated in the Door and Frame Schedule on Drawings.
 - b. Thickness: 1-3/4 inches.
 - c. Face: Uncoated steel sheet, minimum thickness of 0.053 inch.
 - d. Core: Vertical steel stiffener.
 - 2. Frames:
 - a. Materials: Uncoated steel sheet, minimum thickness of 0.053 inch.
 - b. Construction: Full profile welded.
 - 3. Exposed Finish: Prime.

2.3 FRAME ANCHORS

- A. Jamb Anchors:
 - 1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
 - 2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches of frame height above 7 feet.
 - 3. Postinstalled Expansion Anchor: Minimum 3/8-inch- diameter bolts with expansion shields or inserts, with manufacturer's standard pipe spacer.

2.4 MATERIALS

- A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.
- B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.
- C. Inserts, Bolts, and Fasteners: Hot-dip galvanized in accordance with ASTM A153/A153M.
- D. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.
- E. Glazing: Comply with requirements in Section 08 8000 "Glazing."

2.5 FABRICATION

- A. Hollow-Metal Frames: Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames.
 - 1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
 - 2. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.
 - a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
 - b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.
- B. Hardware Preparation: Factory prepare hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping in accordance with ANSI/SDI A250.6, the Door Hardware Schedule on Drawings, and templates.
 - 1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
 - 2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

- C. Glazed Lites: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with butted hairline joints.
 - 1. Provide stops and moldings flush with face of door, and with square stops unless otherwise indicated.
 - 2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
 - 3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames. Provide loose stops and moldings on inside of hollow-metal doors and frames.
 - 4. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.
 - 5. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches o.c. and not more than 2 inches o.c. from each corner.

2.6 STEEL FINISHES

- A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.
 - 1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces. Touch up factory-applied finishes where spreaders are removed.
- B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.2 INSTALLATION

- A. Install hollow-metal doors and frames plumb, rigid, properly aligned, and securely fastened in place. Comply with approved Shop Drawings and with manufacturer's written instructions.
- B. Hollow-Metal Frames: Comply with ANSI/SDI A250.11.
 - 1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces without damage to completed Work.
 - a. Where frames are fabricated in sections, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces. Touch-up finishes.
 - b. Install frames with removable stops located on secure side of opening.
 - 2. Fire-Rated Openings: Install frames in accordance with NFPA 80.

3. Floor Anchors: Secure with postinstalled expansion anchors.
 - a. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if so indicated and approved on Shop Drawings.
 4. Solidly pack mineral-fiber insulation inside frames.
 5. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout or mortar.
 6. In-Place Concrete or Masonry Construction: Secure frames in place with postinstalled expansion anchors. Countersink anchors, and fill and make smooth, flush, and invisible on exposed faces.
 7. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:
 - a. Squareness: Plus or minus 1/16 inch, measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
 - b. Alignment: Plus or minus 1/16 inch, measured at jambs on a horizontal line parallel to plane of wall.
 - c. Twist: Plus or minus 1/16 inch, measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
 - d. Plumbness: Plus or minus 1/16 inch, measured at jambs at floor.
 8. Fire-Rated Doors: Install doors with clearances in accordance with NFPA 80.
 9. Smoke-Control Doors: Install doors in accordance with NFPA 105.
- C. Glazing: Comply with installation requirements in Section 08 8000 "Glazing" and with hollow-metal manufacturer's written instructions.

3.3 REPAIR

- A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.
- B. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION 08 1113

SECTION 08 7100 – DOOR HARDWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes:
 - 1. Mechanical door hardware for:
 - a. Swinging doors.
 - 2. The intent of the hardware specification is to specify the hardware for interior and exterior doors, and to establish a type, continuity, and standard of quality. However, it is the door hardware supplier's responsibility to thoroughly review existing conditions, schedules, specifications, drawings, and other Contract Documents to verify the suitability of the hardware specified.
- B. Exclusions: Unless specifically listed in hardware sets, hardware is not specified in this section for:
 - 1. Windows
 - 2. Cabinets (casework), including locks in cabinets
 - 3. Signage
 - 4. Toilet accessories
 - 5. Overhead doors
- C. Related Sections:
 - 1. Division 06 Section "Rough Carpentry"
 - 2. Division 07 Section "Joint Sealants" for sealant requirements applicable to threshold installation specified in this section.
 - 3. Division 08 Section "Hollow Metal Frames"

1.3 REFERENCES

- A. UL - Underwriters Laboratories
 - 1. UL 10B - Fire Test of Door Assemblies
 - 2. UL 10C - Positive Pressure Test of Fire Door Assemblies
 - 3. UL 1784 - Air Leakage Tests of Door Assemblies
- B. DHI - Door and Hardware Institute
 - 1. Sequence and Format for the Hardware Schedule
 - 2. Recommended Locations for Builders Hardware
 - 3. Key Systems and Nomenclature

- C. ANSI - American National Standards Institute
 - 1. ANSI/BHMA A156.1 - A156.29, and ANSI/BHMA A156.31 - Standards for Hardware and Specialties

1.4 SUBMITTALS

- A. General:
 - 1. Submit in accordance with Conditions of Contract and Division 01 requirements.
 - 2. Highlight, encircle, or otherwise specifically identify on submittals deviations from Contract Documents, issues of incompatibility or other issues which may detrimentally affect the Work.
 - 3. Prior to forwarding submittal, comply with procedures for verifying existing door and frame compatibility for new hardware, as specified in PART 3, "EXAMINATION" article, herein.
- B. Action Submittals:
 - 1. Product Data: Technical product data for each item of door hardware, installation instructions, maintenance of operating parts and finish, and other information necessary to show compliance with requirements.
 - 2. Riser and Wiring Diagrams: After final approval of hardware schedule, submit details of electrified door hardware, indicating:
 - 3. Samples for Verification: If requested by Architect, submit production sample of requested door hardware unit in finish indicated, and tagged with full description for coordination with schedule.
 - a. Samples will be returned to supplier. Units that are acceptable to Architect may, after final check of operations, be incorporated into Work, within limitations of key coordination requirements.
 - 4. Door Hardware Schedule: Submit schedule with hardware sets in vertical format as illustrated by Sequence of Format for the Hardware Schedule as published by the Door and Hardware Institute. Indicate complete designations of each item required for each door or opening, include:
 - a. Door Index; include door number, heading number, and Architects hardware set number.
 - b. Opening Lock Function Spreadsheet: List locking device and function for each opening.
 - c. Quantity, type, style, function, size, and finish of each hardware item.
 - d. Name and manufacturer of each item.
 - e. Fastenings and other pertinent information.
 - f. Location of each hardware set cross-referenced to indications on Drawings.
 - g. Explanation of all abbreviations, symbols, and codes contained in schedule.
 - h. Mounting locations for hardware.
 - i. Door and frame sizes and materials.
 - j. Name and phone number for local manufacturer's representative for each product.
 - 5. Key Schedule:
 - a. Refer to Part 2 – Section 2.12 for Keying Requirements.

- C. Informational Submittals:
 - 1. Qualification Data: For Supplier, Installer and Architectural Hardware Consultant.
 - 2. Product data for electrified door hardware:
 - a. Certify that door hardware approved for use on types and sizes of labeled fire-rated doors complies with listed fire-rated door assemblies.
 - 3. Warranty: Special warranty specified in this Section.
- D. Closeout Submittals:
 - 1. Operations and Maintenance Data: Provide in accordance with Division 01 and include:
 - a. Complete information on care, maintenance, and adjustment; data on repair and replacement parts, and information on preservation of finishes.
 - b. Catalog pages for each product.
 - c. Factory order acknowledgement numbers (for warranty and service)
 - d. Name, address, and phone number of local representative for each manufacturer.
 - e. Parts list for each product.
 - f. Final approved hardware schedule, edited to reflect conditions as-installed.
 - g. Final keying schedule
 - h. Copies of floor plans with keying nomenclature
 - i. Copy of warranties including appropriate reference numbers for manufacturers to identify project.

1.5 QUALITY ASSURANCE

- A. Supplier Qualifications and Responsibilities: Recognized architectural hardware supplier with record of successful in-service performance for supplying door hardware similar in quantity, type, and quality to that indicated for this Project and that provides certified Architectural Hardware Consultant (AHC) or Door Hardware Consultant (DHC) available to Owner, Architect, and Contractor, at reasonable times during the Work for consultation.
 - 1. Warehousing Facilities: In Project's vicinity.
 - 2. Scheduling Responsibility: Preparation of door hardware and keying schedules.
- B. Architectural Hardware Consultant Qualifications: Person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and meets these requirements:
 - 1. For door hardware, DHI-certified, Architectural Hardware Consultant (AHC) or Door Hardware Consultant (DHC).
 - 2. Can provide installation and technical data to Architect and other related subcontractors.
 - 3. Can inspect and verify components are in working order upon completion of installation.
- C. Single Source Responsibility: Obtain each type of door hardware from single manufacturer.

- D. Fire-Rated Door Openings: Provide door hardware for fire-rated openings that complies with NFPA 80 and requirements of authorities having jurisdiction. Provide only items of door hardware that are listed products tested by Underwriters Laboratories, Intertek Testing Services, or other testing and inspecting organizations acceptable to authorities having jurisdiction for use on types and sizes of doors indicated, based on testing at positive pressure and according to NFPA 252 or UL 10C and in compliance with requirements of fire-rated door and door frame labels.
- E. Accessibility Requirements: For door hardware on doors in an accessible route, comply with governing accessibility regulations cited in "REFERENCES" article, herein.
- F. Keying Conference
 - 1. Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system including:
 - a. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.
 - b. Preliminary key system schematic diagram.
 - c. Requirements for key control system.
 - d. Address for delivery of keys.
- G. Pre-installation Conference
 - 1. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Inspect and discuss preparatory work performed by other trades.
 - 3. Review required testing, inspecting, and certifying procedures.
- H. Coordination Conferences:
 - 1. Installation Coordination Conference: Prior to hardware installation, schedule and hold meeting to review questions or concerns related to proper installation and adjustment of door hardware.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Inventory door hardware on receipt and provide secure lock-up for hardware delivered to Project site.
- B. Tag each item or package separately with identification coordinated with final door hardware schedule, and include installation instructions, templates, and necessary fasteners with each item or package.
 - 1. Deliver each article of hardware in manufacturer's original packaging.
- C. Project Conditions:
 - 1. Maintain manufacturer-recommended environmental conditions throughout storage and installation periods.
 - 2. Provide secure lock-up for door hardware delivered to Project. Control handling and installation of hardware items so that completion of Work will not be delayed by hardware losses both before and after installation.

- D. Protection and Damage:
 - 1. Promptly replace products damaged during shipping.
 - 2. Handle hardware in manner to avoid damage, marring, or scratching. Correct, replace or repair products damaged during Work.
 - 3. Protect products against malfunction due to paint, solvent, cleanser, or any chemical agent.

1.7 COORDINATION

- A. Coordinate layout and installation of floor-recessed door hardware with floor construction. Cast anchoring inserts into concrete.
- B. Installation Templates: Distribute for doors, frames, and other work specified to be factory or shop prepared. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.
- C. Security: Coordinate installation of door hardware and keying with Owner's security consultant.

1.8 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Beginning from date of Substantial Completion, for durations indicated.
 - a. Closers:
 - 1) Mechanical: 10 years.
 - b. Locksets:
 - 1) Mechanical: 3 years.
 - c. Key Blanks: Lifetime
 - 2. Warranty does not cover damage or faulty operation due to improper installation, improper use or abuse.

1.9 MAINTENANCE

- A. Maintenance Tools: Furnish complete set of special tools required for maintenance and adjustment of hardware, including changing of cylinders.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The Owner requires use of certain products for their unique characteristics and project suitability to insure continuity of existing and future performance and maintenance standards. After investigating available product offerings, the Awarding Authority has elected to prepare proprietary specifications. These products are specified with the notation: "No Substitute."
 - 1. Where "No Substitute" is noted, submittals and substitution requests for other products will not be considered.
- B. Approval of manufacturers and/or products other than those listed as "Scheduled Manufacturer" or "Acceptable Manufacturers" in the individual article for the product category shall be in accordance with QUALITY ASSURANCE article, herein.
- C. Approval of products from manufacturers indicated in "Acceptable Manufacturers" is contingent upon those products providing all functions and features and meeting all requirements of scheduled manufacturer's product.
- D. Where specified hardware is not adaptable to finished shape or size of members requiring hardware, furnish suitable types having same operation and quality as type specified, subject to Architect's approval.

2.2 MATERIALS

- A. Fasteners
 - 1. Provide hardware manufactured to conform to published templates, generally prepared for machine screw installation.
 - 2. Furnish screws for installation with each hardware item. Finish exposed (exposed under any condition) screws to match hardware finish, or, if exposed in surfaces of other work, to match finish of this other work including prepared for paint surfaces to receive painted finish.
 - 3. Provide concealed fasteners for hardware units exposed when door is closed except when no standard units of type specified are available with concealed fasteners. Do not use thru-bolts for installation where bolt head or nut on opposite face is exposed in other work unless thru-bolts are required to fasten hardware securely. Review door specification and advise Architect if thru-bolts are required.
 - 4. Install hardware with fasteners provided by hardware manufacturer.
- B. Provide screws, bolts, expansion shields, drop plates and other devices necessary for hardware installation.
 - 1. Where fasteners are exposed to view: Finish to match adjacent door hardware material.

2.3 HINGES

- A. Manufacturers and Products:
 - 1. Scheduled Manufacturer and Product: Ives 5BB Series.

2. Acceptable Manufacturers and Products: Hager BB Series, McKinney TA/T4A Series, Stanley FBB Series.

B. Requirements:

1. Provide hinges conforming to ANSI/BHMA A156.1.
2. 1-3/4 inch (44 mm) thick doors, up to and including 36 inches (914 mm) wide:
 - a. Exterior: Standard weight, bronze or stainless steel, 4-1/2 inches (114 mm) high
 - b. Interior: Standard weight, steel, 4-1/2 inches (114 mm) high
3. 1-3/4 inch (44 mm) thick doors over 36 inches (914 mm) wide:
 - a. Exterior: Heavy weight, bronze/stainless steel, 5 inches (127 mm) high
 - b. Interior: Heavy weight, steel, 5 inches (127 mm) high
4. 2 inches or thicker doors:
 - a. Exterior: Heavy weight, bronze or stainless steel, 5 inches (127 mm) high
 - b. Interior: Heavy weight, steel, 5 inches (127 mm) high
5. Provide three hinges per door leaf for doors 90 inches (2286 mm) or less in height, and one additional hinge for each 30 inches (762 mm) of additional door height.
6. Where new hinges are specified for existing doors or existing frames, provide new hinges of identical size to hinge preparation present in existing door or existing frame.
7. Hinge Pins: Except as otherwise indicated, provide hinge pins as follows:
 - a. Steel Hinges: Steel pins
 - b. Non-Ferrous Hinges: Stainless steel pins
 - c. Out-Swinging Exterior Doors: Non-removable pins
 - d. Out-Swinging Interior Lockable Doors: Non-removable pins
 - e. Interior Non-lockable Doors: Non-rising pins
8. Width of hinges: 4-1/2 inches (114 mm) at 1-3/4 inch (44 mm) thick doors, and 5 inches (127 mm) at 2 inches (51 mm) or thicker doors. Adjust hinge width as required for door, frame, and wall conditions to allow proper degree of opening.
9. Provide hinges with electrified options as scheduled in the hardware sets. Provide with sufficient number and wire gage to accommodate electric function of specified hardware. Locate electric hinge at second hinge from bottom or nearest to electrified locking component.

2.4 CYLINDRICAL LOCKS

A. Manufacturers and Products:

1. Scheduled Manufacturer and Product: Schlage ND Series.
2. Acceptable Manufacturers and Products: Best 9K3 Series, Sargent 11-Line Series.

B. Requirements:

1. Provide cylindrical locks conforming to ANSI/BHMA A156.2 Series 4000, Grade 1, and UL Listed for 3-hour fire doors.
2. Cylinders: Refer to "KEYING" article, herein.
3. Provide locks with standard 2-3/4 inches (70 mm) backset, unless noted otherwise, with 1/2-inch latch throw. Provide proper latch throw for UL listing at pairs.
4. Provide locksets with separate anti-rotation thru-bolts, and no exposed screws.

5. Provide independently operating levers with two external return spring cassettes mounted under roses to prevent lever sag.
6. Provide standard ASA strikes unless extended lip strikes are necessary to protect trim.
7. Provide electrified options as scheduled in the hardware sets.
8. Lever Trim: Solid cast levers without plastic inserts and wrought roses on both sides.
 - a. Lever Design: RHO.

2.5 CYLINDERS

- A. Manufacturers:
 1. Scheduled Manufacturer: Schlage.
 2. Acceptable Manufacturers and Products: No Substitution.
- B. Requirements:
 1. Provide interchangeable cylinders to match Owner's existing key system, compliant with ANSI/BHMA A156.5; latest revision; cylinder face finished to match lockset, manufacturer's series as indicated. Refer to "KEYING" article, herein.
 2. Provide the following keyway: Schlage SFIC cores shall be furnished by GRPS.
- C. Construction Keying:
 1. Replaceable Construction Cores.
 - a. Provide temporary construction cores replaceable by permanent cores, furnished in accordance with the following requirements.
 - 1) 3 construction control keys
 - 2) 12 construction change (day) keys.
 - b. Owner or Owner's Representative will replace temporary construction cores with permanent cores.

2.6 KEYING

- A. Provided by GRPS.

2.7 DOOR CLOSERS

- A. Manufacturers and Products:
 1. Scheduled Manufacturer and Product: LCN 4040XP Series.
 2. Acceptable Manufacturers and Products: Sargent 281 Series.
- B. Requirements:
 1. Provide door closers conforming to ANSI/BHMA A156.4 Grade 1 requirements by BHMA certified independent testing laboratory. ISO 9000 certify closers. Stamp units with date of manufacture code.
 2. Provide door closers with fully hydraulic, full rack and pinion action with high strength cast iron cylinder, and full complement bearings at shaft.
 3. Cylinder Body: 1-1/2 inch (38 mm) diameter with 5/8 inch (16 mm) diameter double heat-treated pinion journal.

4. Hydraulic Fluid: Fireproof, passing requirements of UL10C, and requiring no seasonal closer adjustment for temperatures ranging from 120 degrees F to -30 degrees F.
5. Spring Power: Continuously adjustable over full range of closer sizes, and providing reduced opening force as required by accessibility codes and standards.
6. Hydraulic Regulation: By tamper-proof, non-critical valves, with separate adjustment for latch speed, general speed, and backcheck.
7. Provide closers with solid forged steel main arms and factory assembled heavy-duty forged forearms for parallel arm closers.
8. Pressure Relief Valve (PRV) Technology: Not permitted.
9. Finish for Closer Cylinders, Arms, Adapter Plates, and Metal Covers: Powder coating finish which has been certified to exceed 100 hours salt spray testing as described in ANSI Standard A156.4 and ASTM B117, or has special rust inhibitor (SRI).
10. Provide special templates, drop plates, mounting brackets, or adapters for arms as required for details, overhead stops, and other door hardware items interfering with closer mounting.
11. Provide through-bolts for wood door closers.

2.8 PROTECTION PLATES

- A. Manufacturers:
 1. Scheduled Manufacturer: Ives.
 2. Acceptable Manufacturers: Trimco, Rockwood.
- B. Requirements:
 1. Provide kick plates, mop plates, and armor plates minimum of 0.050 inch (1 mm) thick, beveled four edges as scheduled. Furnish with sheet metal or wood screws, finished to match plates.
 2. Sizes of plates:
 - a. Kick Plates: 10 inches (254 mm) high by 2 inches (51 mm) less width of door on single doors, 1 inch (25 mm) less width of door on pairs

2.9 DOOR STOPS AND HOLDERS

- A. Manufacturers:
 1. Scheduled Manufacturer: Ives.
 2. Acceptable Manufacturers: Trimco, Rockwood.
- B. Provide door stops at each door leaf:
 1. Provide wall stops wherever possible. Provide convex type where mortise type locks are used and concave type where cylindrical type locks are used.
 2. Where a wall stop cannot be used, provide universal floor stops for low or high rise options.
 3. Where wall or floor stop cannot be used, provide medium duty surface mounted overhead stop.

2.10 THRESHOLDS, SEALS, DOOR SWEEPS, AUTOMATIC DOOR BOTTOMS, AND GASKETING

- A. Manufacturers:
 - 1. Scheduled Manufacturer: Zero International.
 - 2. Acceptable Manufacturers: National Guard, Reese, Pemko
- B. Requirements:
 - 1. Provide thresholds, weather-stripping (including door sweeps, seals, and astragals) and gasketing systems (including smoke, sound, and light) as specified and per architectural details. Match finish of other items.
 - 2. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that meets requirements of assemblies tested according to UL 1784 and installed in compliance with NFPA 105.
 - 3. Provide door sweeps, seals, astragals, and auto door bottoms only of type where resilient or flexible seal strip is easily replaceable and readily available.

2.11 FINISHES

- A. Finish: Generally, satin chromium BHMA 626/652 (US26D). Provide finish for each item as indicated in sets.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Prior to installation of hardware, examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire-rated door assembly construction, wall and floor construction, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Mount door hardware units at heights to comply with the following, unless otherwise indicated or required to comply with governing regulations.
 - 1. Standard Steel Doors and Frames: ANSI/SDI A250.8.
 - 2. Custom Steel Doors and Frames: HMMA 831.
- B. Install each hardware item in compliance with manufacturer's instructions and recommendations, using only fasteners provided by manufacturer.
- C. Do not install surface mounted items until finishes have been completed on substrate. Protect all installed hardware during painting.
- D. Set units level, plumb and true to line and location. Adjust and reinforce attachment substrate as necessary for proper installation and operation.

- E. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
- F. Install operating parts so they move freely and smoothly without binding, sticking, or excessive clearance.
- G. Hinges: Install types and in quantities indicated in door hardware schedule but not fewer than quantity recommended by manufacturer for application indicated or one hinge for every 30 inches (750 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.
- H. Lock Cylinders: Install construction cores to secure building and areas during construction period.
 - 1. Owner shall replace construction cores with permanent cores as indicated in keying section.
- I. Key Control System: Tag keys and place them on markers and hooks in key control system cabinet, as determined by final keying schedule.
- J. Door Closers: Mount closers on room side of corridor doors, inside of exterior doors, and stair side of stairway doors from corridors. Mount closers so they are not visible in corridors, lobbies and other public spaces unless approved by Architect.
- K. Closer/Holders: Mount closer/holders on room side of corridor doors, inside of exterior doors, and stair side of stairway doors.
- L. Stops: Provide floor stops for doors unless wall or other type stops are indicated in door hardware schedule. Do not mount floor stops where they may impede traffic or present tripping hazard.
- M. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

3.3 FIELD QUALITY CONTROL

- A. Engage qualified manufacturer trained representative to perform inspections and to prepare inspection reports.
 - 1. Representative will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.4 ADJUSTING

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.
 - 1. Door Closers: Adjust sweep period to comply with accessibility requirements and requirements of authorities having jurisdiction.

- B. Occupancy Adjustment: Approximately three to six months after date of Substantial Completion, Installer's Architectural Hardware Consultant must examine and readjust each item of door hardware, including adjusting operating forces, as necessary to ensure function of doors and door hardware.

3.5 CLEANING AND PROTECTION

- A. Clean adjacent surfaces soiled by door hardware installation.
- B. Clean operating items as necessary to restore proper function and finish.
- C. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of Substantial Completion.

3.6 DOOR HARDWARE SCHEDULE

- A. Hardware items are referenced in the following hardware. Refer to the above-specifications for special features, options, cylinders/keying, and other requirements.
- B. Hardware Sets:

Hardware Group No. 01

For use on Door #(s):

127A.1 128A.1 130A.1 131A.1 132A.1 133A.1

Each to have:

QTY		DESCRIPTION	CATALOG NUMBER	FINISH	MFR
3	EA	HINGE	5BB1HW 4.5 X 4.5	652	IVE
1	EA	CORRIDOR LOCK W/OUTSIDE INDICATOR	ND73BDC RHO OS-OCC	626	SCH
1	EA	SFIC PERMANENT CORE	PROVIDED BY OWNER	626	SCH
1	EA	WALL STOP	WS406/407CCV	630	IVE
1	EA	GASKETING	488S	BK	ZER

Hardware Group No. 02

For use on Door #(s):

130.1

Each to have:

QTY		DESCRIPTION	CATALOG NUMBER	FINISH	MFR
3	EA	HINGE	5BB1HW 4.5 X 4.5 NRP	652	IVE
1	EA	CLASSROOM SECURITY W/INSIDE INDICATOR	ND78BDC RHO IS-CRS	626	SCH
2	EA	SFIC PERMANENT CORE	PROVIDED BY OWNER	626	SCH
1	EA	SURFACE CLOSER	4040XP RW/PA - PUSH-SIDE	689	LCN
1	EA	KICK PLATE	8400 10" X 2" LDW B-CS	630	IVE
1	EA	WALL STOP	WS406/407CCV	630	IVE
1	EA	GASKETING	488S	BK	ZER

END OF SECTION 08 7100

SECTION 08 8000 - GLAZING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Glass products.
 - 2. Glazing sealants.
 - 3. Miscellaneous glazing materials.
- B. Related Requirements:
 - 1. Section 08 1113 "Hollow Metal Doors and Frames".

1.2 COORDINATION

- A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances to achieve proper safety margins for glazing retention under each design load case, load case combination, and service condition.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protect glazing materials in accordance with manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.
- B. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
 - 1. For monolithic-glass lites, properties are based on units with lites 6 mm thick.
 - 2. SHGC and Visible Transmittance: Center-of-glazing values, in accordance with NFRC 200 and based on most current non-beta version of LBL's WINDOW computer program.
 - 3. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.2 GLASS PRODUCTS, GENERAL

- A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.
 - 1. NGA Publications: "Glazing Manual."
- B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
- C. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than thickness indicated.
- D. Strength: Where annealed float glass is indicated, provide annealed float glass, heat-strengthened float glass, or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass as needed to comply with "Performance Requirements" Article. Where fully tempered float glass is indicated, provide fully tempered float glass.

2.3 GLASS PRODUCTS

- A. Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

2.4 GLAZING SEALANTS

- A. General:
 - 1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 - 2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
- B. Neutral-Curing Silicone Glazing Sealant, Class 100/50: Complying with ASTM C920, Type S, Grade NS, Use NT.
- C. General: Provide products of material, size, and shape complying with referenced glazing standard, recommended in writing by manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
- D. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

- E. Setting Blocks:
 - 1. EPDM or Silicone with Shore A durometer hardness of 85, plus or minus 5.
 - 2. Type recommended in writing by sealant or glass manufacturer.
- F. Spacers:
 - 1. Neoprene blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.
 - 2. Type recommended in writing by sealant or glass manufacturer.
- G. Edge Blocks:
 - 1. EPDM or Silicone with Shore A durometer hardness per manufacturer's written instructions.
 - 2. Type recommended in writing by sealant or glass manufacturer.

2.5 FABRICATION OF GLAZING UNITS

- A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
 - 1. Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:
 - 1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
 - 2. Presence and functioning of weep systems.
 - 3. Minimum required face and edge clearances.
 - 4. Effective sealing between joints of glass-framing members.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

3.3 GLAZING, GENERAL

- A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

- B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.
- C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
- D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
- E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
- F. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.

3.4 GASKET GLAZING (DRY)

- A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
- B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.
- C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.
- D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended in writing by gasket manufacturer.
- E. Install gaskets so they protrude past face of glazing stops.

3.5 CLEANING AND PROTECTION

- A. Immediately after installation, remove nonpermanent labels and clean surfaces.

- B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
 - 1. If, despite such protection, contaminating substances do contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.
- C. Remove and replace glass that is damaged during construction period.
- D. Wash glass on both exposed surfaces not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

3.6 MONOLITHIC GLASS SCHEDULE

- A. Clear Glass Type: Fully tempered float glass.
 - 1. Minimum Thickness: 6 mm.
 - 2. Safety glazing required.

END OF SECTION 08 8000

SECTION 08 9119 - FIXED LOUVERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fixed extruded-aluminum louvers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.
- B. Sample Warranties: For manufacturer's special warranties.

1.4 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.5 WARRANTY

- A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.
 - 1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.
- B. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.
- D. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.2 FIXED EXTRUDED-ALUMINUM LOUVERS

- A. Horizontal Drainable-Blade Louver, Extruded Aluminum:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance; MESTEK, Inc.
 - b. Greenheck Fan Corporation
 - c. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - 2. Louver Depth: 4 inches.
 - 3. Frame and Blade Nominal Thickness: Not less than 0.080 inch.
 - 4. Mullion Type: Exposed.
 - 5. Louver Performance Ratings:
 - a. Refer to schedule on drawings.
 - 6. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.3 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
 - 1. Screen Location for Fixed Louvers: Interior face.
 - 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with stainless steel machine screws, spaced a maximum of 6 inches from each corner and at 12 inches o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 - 1. Metal: Same type and form of metal as indicated for louver to which screens are attached.
 - 2. Finish: Same finish as louver frames to which louver screens are attached.
- D. Louver Screening for Aluminum Louvers:
 - 1. Bird Screening, Aluminum: 1/2-inch- square mesh, 0.063-inch wire.

2.4 MATERIALS

- A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5, T-52, or T6.

2.5 FABRICATION

- A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

2.6 ALUMINUM FINISHES

- A. Finish louvers after assembly.
- B. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - 1. Color and Gloss: As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

- E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 07 9200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

- A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION 08 9119

SECTION 09 2216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Nonstructural steel framing.
 - 2. Grid suspension systems.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- B. Protect materials from corrosion, deformation, and other damage during delivery, storage, and handling in accordance with AISI S202.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. STC-Rated Assemblies: Where indicated on Drawings, provide assemblies incorporating nonstructural framing identical to those of assemblies tested in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.
- B. Design Loads: As indicated on architectural drawings or 5 lbf/sq. ft. minimum as

2.2 NONSTRUCTURAL STEEL FRAMING

- A. Framing Members, General: Comply with requirements in AISI S220 for conditions indicated on Drawings.
 - 1. Protective Coating: ASTM A653/A653M, G40 or coating with demonstrated equivalent corrosion resistance. Galvannealed products are unacceptable.
 - a. Equivalent Corrosion-Resistant Coating: Evaluation report acceptable to authorities having jurisdiction demonstrates corrosion resistance equivalent to specified protective coating.
- B. Studs and Track: Conventional members, roll-formed into standard shapes without surface deformations to stiffen framing members.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich
 - b. Jaimes Industries, Inc.

- c. Marino\WARE
 - d. Steel Network, Inc. (The)
 - e. TELLING Industries
 - f. Approved Equivalent
 - 2. Minimum Base-Steel Thickness: 0.0329 inch
 - 3. Minimum Yield Strength: 33 ksi.
 - 4. Depth: As indicated on Drawings.
- C. Slip-Type Head Joints: Where indicated on Drawings, provide one of the following:
- 1. Clip System: Clips designed for use in head-of-wall deflection conditions that provide a positive attachment of studs to track while allowing 1-1/2-inch minimum vertical movement.
 - 2. Single Long-Leg Track: Top track with solid, 2-inch- deep flanges in base-steel thickness not less than that of studs, installed with studs friction fit into track and with continuous bridging located within 12 inches of the top of studs to provide lateral bracing.
 - 3. Slotted Deflection Track: Steel sheet top track manufactured with 2-1/2-inch- deep flanges that allow positive attachment to studs through long slots and prevent deflection of structure above from cracking finishes applied to framing; in base-steel thickness not less than that of studs and in width to accommodate depth of studs.
 - 4. Double-Track System: Top outer track sized to friction-fit over inner track and inner track with 2-inch- deep flanges in base-steel thickness not less than that of studs and fastened to studs.
- D. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated on Drawings.
- 1. Minimum Base-Steel Thickness: 0.0329 inch.

2.3 GRID SUSPENSION SYSTEMS

- A. Grid Suspension Systems for Gypsum Board Ceilings: ASTM C645, direct-hung system composed of main beams and cross-furring members that interlock.
- 1. Manufacturers: Basis-of-Design: Subject to compliance with requirements, provide Rockfon; Chicago Metallic Drywall Grid: 640 Drywall Suspension System or a comparable product by one of the following
 - a. Armstrong Ceiling & Wall Solutions
 - b. CertainTeed; SAINT-GOBAIN
 - c. USG Corporation

2.4 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards.
- 1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.
- B. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
- 1. Adjustable Wall-Furring Brackets for Tie Wire: Use minimum double strand of 0.0625-inch- diameter wire, or triple strand of 0.0475-inch- diameter wire to attach furring channels.

2. Suspended-Ceiling Systems:
 - a. Splicing Carrying Channels and Furring Members: Use double loops of minimum 0.0625-inch- diameter wire.
 - b. Saddle Tying Main Runners and Cross Furring: Use minimum 0.0625-inch- diameter wire, or double strand of 0.0475-inch- diameter wire.
- C. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.162 inch in diameter.
- D. Flat Hangers: ASTM A653/A653M hot-dip galvanized steel sheet, 1 by 3/16 inch by length indicated on Drawings.
- E. Isolation Strip at Exterior Walls: Provide one of the following:
 1. Asphalt-Saturated Organic Felt: ASTM D226/D226M, Type I (No. 15 asphalt felt), nonperforated.
 2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, substrates, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF NONSTRUCTURAL METAL FRAMING, GENERAL

- A. Installation Standard: ASTM C754.
 1. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.
- B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.
- C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- D. Install bracing at terminations in assemblies.
- E. Do not bridge building control and expansion joints with framing members. Frame both sides of joints independently.

3.3 INSTALLATION OF NONSTRUCTURAL STEEL FRAMING

- A. Install framing system components at spacings indicated on Drawings, but not greater than spacings required by referenced installation standards for assembly types.
 1. Single-Layer Application: 16 inches o.c. unless otherwise indicated on Drawings.

2. Tile Backing Panels: 16 inches o.c. unless otherwise indicated on Drawings.
- B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.
- C. Install studs so flanges within framing system point in same direction.
- D. Install track at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated on Drawings to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.
 1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
 2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
 - a. Install two studs at each jamb unless otherwise indicated on Drawings.
 - b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch clearance from jamb stud to allow for installation of control joint in finished assembly.
 - c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure unless otherwise indicated on Drawings.
 3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated on Drawings. Install framing below sills of openings to match framing required above door heads.
- E. Direct Furring:
 1. Screw to wood framing.
 2. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches o.c.
- F. Suspended Assemblies: Isolate suspension assemblies from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.
 1. Hangers: Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural.
 - a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - b. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.
 - 1) Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

- c. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
 - d. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
 - e. Do not attach hangers to steel roof deck.
 - f. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.
 - g. Do not connect or suspend framing from ducts, pipes, or conduit.
- G. Installation Tolerances for Nonstructural Steel Framing:
- 1. Framing Members: Install each framing member so fastening surfaces vary not more than 1/8 inch from the plane formed by faces of adjacent framing.
 - 2. Suspended Assemblies: Install suspension systems that are level to within 1/8 inch in 12 ft. measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

3.4 INSTALLATION OF GRID SUSPENSION SYSTEMS

- A. Grid Suspension Systems: Install in accordance with manufacturer's written instructions. Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.
- B. Installation Tolerances for Grid Suspension Systems: Install suspension systems that are level to within 1/8 inch in 12 ft. measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION 09 2216

SECTION 09 2900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior gypsum board.
- B. Related Requirements:
 - 1. Section 09 2216 "Non-Structural Metal Framing" for nonstructural steel framing and suspension systems that support gypsum board panels.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.4 FIELD CONDITIONS

- A. Environmental Limitations: Comply with ASTM C840 requirements or manufacturer's written instructions, whichever are more stringent.
- B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.
- C. Do not install panels that are wet, moisture damaged, or mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of gypsum panel and joint finishing material from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings in accordance with ASTM E119; tested by a qualified testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings in accordance with ASTM E90 and classified in accordance with ASTM E413; tested by a qualified testing agency.

2.3 GYPSUM BOARD, GENERAL

- A. Size: Provide panel products in maximum lengths and widths available that will minimize joints in each area and that correspond with support system specified or indicated on Drawings.

2.4 INTERIOR GYPSUM BOARD

- A. Abuse-Resistant Gypsum Board: ASTM C1396/C1396M, tested in accordance with ASTM C1629/C1629M.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Extreme Impact Resistant Gypsum Board.
 - b. Continental Building Products; Protecta HIR 300 Type X with Mold Defense.
 - c. National Gypsum Company; Gold Bond Brand Hi-Impact XP Gypsum Board.
 - d. USG Corporation; Sheetrock Brand Mold Tough VHI Firecode X Panels.
 - e. Approved Equivalent
 - 2. Core: As indicated on Drawings 5/8 inch, Type X.
 - 3. Surface Abrasion: ASTM C1629/C1629M, meets or exceeds Level 2 requirements.
 - 4. Indentation: ASTM C1629/C1629M, meets or exceeds Level 1 requirements.
 - 5. Soft-Body Impact: ASTM C1629/C1629M, meets or exceeds Level 3 requirements.
 - 6. Mold Resistance: ASTM D3273, score of 10 as rated in accordance with ASTM D3274.
 - 7. Long Edges: Tapered.

2.5 TRIM ACCESSORIES

- A. Interior Trim: ASTM C1047.
 - 1. Material: Galvanized-steel sheet or aluminum-coated steel sheet or rolled zinc.
 - 2. Shapes:
 - a. Cornerbead.
 - b. LC-Bead: J-shaped; exposed long flange receives joint compound.
 - c. L-Bead: L-shaped; exposed long flange receives joint compound.

- d. U-Bead: J-shaped; exposed short flange does not receive joint compound.
- e. Expansion (control) joint.

2.6 JOINT TREATMENT MATERIALS

- A. General: Comply with ASTM C475/C475M requirements.
- B. Joint Tape:
 - 1. Interior Gypsum Board: Paper.
- C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.
 - 1. Prefilling: At open joints and damaged surface areas, use setting-type taping compound.
 - 2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.
 - 3. Fill Coat: For second coat, use drying-type, all-purpose compound.
 - 4. Finish Coat: For third coat, use drying-type, all-purpose compound.

2.7 AUXILIARY MATERIALS

- A. Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.
- B. Steel Drill Screws: ASTM C1002 unless otherwise specified or indicated on Drawings.
 - 1. Use screws complying with ASTM C954 for fastening panels to steel members from 0.033 to 0.112 inch thick.
 - 2. For fastening cementitious backer units, use screws of type and size recommended in writing by panel manufacturer.
- C. Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers as follows:
 - 1. Non-Fire-Resistance-Rated Assemblies: slag or rock wool.
 - 2. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION AND FINISHING OF PANELS, GENERAL

- A. Comply with ASTM C840 requirements.
- B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch of open space between panels. Do not force into place.
- D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- E. Form control and expansion joints with space between edges of adjoining gypsum panels.
- F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - 1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. in area.
 - 2. Fit gypsum panels around ducts, pipes, and conduits.
 - 3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- wide joints to install sealant.
- G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
- I. Wood Framing: Install gypsum panels over wood framing, with floating internal corner construction. Do not attach gypsum panels across the flat grain of wide-dimension lumber, including floor joists and headers. Float gypsum panels over these members or provide control joints to counteract wood shrinkage.
- J. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919 requirements and with manufacturer's written instructions for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.

- K. Install sound-attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 INSTALLATION OF INTERIOR GYPSUM BOARD

- A. Single-Layer Application:
 - 1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated on Drawings.
 - 2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing) unless otherwise specified or indicated on Drawings or required by fire-resistance-rated assembly, and minimize end joints.
 - a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - 3. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.4 INSTALLATION OF TRIM ACCESSORIES

- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim in accordance with manufacturer's written instructions.
- B. Control Joints: Install control joints in accordance with ASTM C840 and in specific locations approved by Architect for visual effect.
- C. Interior Trim: Install in the following locations:
 - 1. Cornerbead: Install at outside corners unless otherwise specified or indicated on Drawings.
 - 2. LC-Bead: Install at exposed panel edges.

3.5 APPLICATION OF JOINT TREATMENT MATERIALS

- A. Finishing Panel Products: Treat joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare panel surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Prefill open joints and damaged surface areas.
- C. Apply joint tape over panel joints, except for trim products specifically indicated as not intended to receive tape.
- D. Interior Gypsum Board: Finish panels to levels indicated below and in accordance with ASTM C840:
 - 1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
 - 2. Level 2: In utility areas, behind cabinetry, and in similar locations that shall not be painted or finished, and at tile backing board to receive tile finish.
 - 3. Level 3: At panel surfaces that will be exposed to view unless otherwise indicated.
 - 4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.

3.6 PROTECTION

- A. Protect adjacent surfaces from joint compound and promptly remove from floors and other non-gypsum board surfaces. Repair surfaces stained, marred, or otherwise damaged during gypsum board installation and finishing.
- B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- C. Remove and replace panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION 09 2900

SECTION 09 3013 - CERAMIC TILING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Porcelain tile.
 - 2. Ceramic mosaic tile.
 - 3. Glazed wall tile.
 - 4. Crack isolation membranes.
 - 5. Setting material.
 - 6. Grout materials.
- B. Related Requirements:
 - 1. Section 07 9200 "Joint Sealants" for sealing of movement joints in tile surfaces.

1.2 DEFINITIONS

- A. General: Definitions in ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.
- B. Face Size: Actual tile size, excluding spacer lugs.
- C. Module Size: Actual tile size plus joint width indicated.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show locations, plans, and elevations, of each type of tile and tile pattern. Show widths, details, and locations of movement joints in tile substrates and finished tile surfaces.
- C. Samples for Verification:
 - 1. Full-size units of each type and composition of tile and for each color and finish required.
 - 2. Full-size units of each type of trim and accessory for each color and finish required.
 - 3. Metal flooring transitions 6-inch lengths.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.

2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installer is a Five-Star member of the National Tile Contractors Association or a Trowel of Excellence member of the Tile Contractors' Association of America.
 2. Installer's supervisor for Project holds the International Masonry Institute's Supervisor Certification.
 3. Installer employs only Ceramic Tile Education Foundation Certified Installers or installers recognized by the U.S. Department of Labor as Journeyman Tile Layers for Project.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.
- B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.
- D. Store liquid materials in unopened containers and protected from freezing.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

1.8 WARRANTY

- A. Warranty Period: Five years from date of Product Purchase.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Tile: Obtain tile of each type from single source or producer.
 1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

2.2 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
 - 1. Provide tile complying with Standard Grade requirements unless otherwise indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.

2.3 PORCELAIN TILE

- A. Porcelain Tile Type (T-1, T-2, T-3, T-4, T-5): Unglazed.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Daltile; Keystones or comparable product by one of the following:
 - a. American Olean; a brand of Dal-Tile Corporation
 - 2. Certification: Tile certified by the Porcelain Tile Certification Agency.
 - 3. Face Size: As indicated on drawings.
 - 4. Face Size Variation: Rectified.
 - 5. Thickness: 1/4 inch.
 - 6. Product Use Classification: Interior, Wet (IW).
 - 7. Tile Color, Glaze, and Pattern: As indicated on drawings.
 - 8. Grout Color: As indicated on drawings.

2.4 PORCELAIN TILE

- A. Porcelain Tile Type (T-7): Unglazed.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Tile Bar; New Rock Fossil or comparable product by one of the following:
 - a. Atlas Concorde
 - b. Tile Bar
 - c. Genrose Stone + Tile
 - d. Platform Surfaces
 - 2. Certification: Tile certified by the Porcelain Tile Certification Agency.
 - 3. Face Size: As indicated on drawings.
 - 4. Face Size Variation: Rectified.
 - 5. Thickness: 1/4 inch.
 - 6. Product Use Classification: Interior, Wet (IW).
 - 7. Tile Color, Glaze, and Pattern: As indicated on drawings.
 - 8. Grout Color: As indicated on drawings.

2.5 GLAZED WALL TILE

- A. Glazed Wall Tile Type (T-6):
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Daltile; Color Wheel or comparable product by one of the following:
 - a. American Olean; a brand of Dal-Tile Corporation

2. Module Size: As indicated on drawings.
3. Face Size Variation: Rectified.
4. Thickness: 5/16 inch.
5. Tile Color and Pattern: As indicated on drawings.
6. Grout Color: As indicated on drawings.

2.6 CRACK ISOLATION MEMBRANES

- A. General: Manufacturer's standard product that complies with ANSI A118.12 for high performance and is recommended by manufacturer for application indicated. Include reinforcement and accessories recommended by manufacturer.
- B. Crack Isolation Membrane, Polyethylene Sheet: Polyethylene faced on both sides with polyester fabric.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Schluter Systems L.P.

2.7 SETTING MATERIALS

- A. Improved Modified Dry-Set Mortar (Thinset): ANSI A118.15.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Custom Building Products
 - b. H.B. Fuller Construction Products Inc. / TEC
 - c. Laticrete International, Inc.
 - d. MAPEI Corporation
 2. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
 3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to other requirements in ANSI A118.15.

2.8 GROUT MATERIALS

- A. Sand-Portland Cement Grout: ANSI A108.10, consisting of white or gray cement and white or colored aggregate as required to produce color indicated.
- B. High-Performance Tile Grout: ANSI A118.7.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Custom Building Products
 - b. H.B. Fuller Construction Products Inc. / TEC
 - c. Laticrete International, Inc.
 - d. MAPEI Corporation
 2. Polymer Type:
 - a. Dry, redispersible form, prepackaged with other dry ingredients.

2.9 MISCELLANEOUS MATERIALS

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting and adhesive materials for installations indicated.
- B. Vapor-Retarder Membrane: Polyethylene sheeting, ASTM D4397, 4.0 mils thick.
- C. Metal Flooring Transitions: Profile designed specifically for flooring applications; height to match tile and setting-bed thickness.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Schluter Systems L.P.
 - 2. Description: As indicated on drawings.
 - 3. Material and Finish: As indicated on drawings.
 - a. Color: As indicated on drawings.
- D. Temporary Protective Coating: Formulated to protect exposed surfaces of tile against adherence of mortar and grout; compatible with tile, mortar, and grout products and easily removable after grouting is completed without damaging grout or tile.
- E. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.
- F. Grout Sealer: Grout manufacturer's standard product for sealing grout joints that does not change color or appearance of grout.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
 - 2. Verify that concrete substrates for tile floors installed with thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
 - a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
 - b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.
 - 3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.
 - 4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove coatings, including curing compounds or other coatings, that are incompatible with tile-setting materials.
- B. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with thinset mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.
- C. Where indicated, prepare substrates to receive waterproof membrane by applying a reinforced mortar bed that complies with ANSI A108.1 and is sloped 1/4 inch per foot toward drains.
- D. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.
- E. Substrate Flatness:
 - 1. For tile shorter than 15 inches, confirm that structure or substrate is limited to variation of 1/4 inch in 10 ft. from the required plane, and no more than 1/16 inch in 12 inches when measured from tile surface high points.
 - 2. For large format tile, tile with at least one edge 15 inches or longer, confirm that structure or substrate is limited to 1/8 inch in 10 ft. from the required plane, and no more than 1/16 inch in 24 inches when measured from tile surface high points.

3.3 INSTALLATION OF CERAMIC TILE SYSTEM

- A. Install tile backing panels and treat joints in accordance with ANSI A108.11 and manufacturer's written instructions for type of application indicated.
- B. Install waterproof membrane to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness that is bonded securely to substrate.
 - 1. Allow waterproof membrane to cure and verify by testing that it is watertight before installing tile or setting materials over it.
- C. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.
 - 1. Allow crack isolation membrane to cure before installing tile or setting materials over it.
- D. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
 - 1. Add materials, water, and additives in accurate proportions.

2. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.
- E. Install tile in accordance with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 series that are referenced in TCNA installation methods and specified in tile installation schedules, and apply to types of setting and grouting materials used.
1. For the following installations, follow procedures in ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
 - a. Exterior tile floors and walls.
 - b. Tile floors in wet areas.
 - c. Tile swimming pool decks.
 - d. Tile floors in laundries.
 - e. Tile floors consisting of tiles 8 by 8 inches or larger.
 - f. Tile floors consisting of rib-backed tiles.
 2. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
 3. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
 4. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.
 5. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.
 6. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
 - a. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets, so joints between sheets are not apparent in finished Work.
 - b. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
 - c. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.
 7. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

- F. Movement Joints: Provide movement joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated on Drawings. Form joints during installation of setting materials, mortar beds, and tile. Keep joints free of dirt, debris, and setting materials prior to filling with sealants. Do not saw-cut joints after installing tiles.
 - 1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
- G. Metal Flooring Transitions: Install where exposed edge of tile flooring meets carpet, wood, or other flooring that finishes flush with or below top of tile and no threshold is indicated.
- H. Metal Wall Trim: Install at locations indicated on Drawings.
- I. Grout Sealer: Apply grout sealer to cementitious grout joints in tile floors in accordance with manufacturer's written instructions. As soon as sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.

3.4 ADJUSTING AND CLEANING

- A. Remove and replace tile that is damaged or that does not match adjoining tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.
- B. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
 - 1. Remove grout residue from tile as soon as possible.
 - 2. Clean grout smears and haze from tile in accordance with tile and grout manufacturer's written instructions. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3.5 PROTECTION

- A. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.
- B. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.6 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE

- A. Interior Floor Installations, Concrete Subfloor:
 - 1. TCNA F125-Full: Thinset mortar on crack isolation membrane.
 - a. Thinset Mortar: Improved modified dry-set mortar.
 - b. Grout: High-performance sanded cement grout.
 - c. Crack Isolation Membrane: Polyethylene sheet.
 - d. Joint Width: 1/8 inch.
- B. Interior Wall Installations, Masonry or Concrete:
 - 1. TCNA W202I: Thinset mortar.
 - a. Thinset Mortar: Improved modified dry-set mortar.
 - b. Grout: High-performance sanded cement grout.
 - c. Joint Width: 1/8 inch.

END OF SECTION 09 3013

SECTION 09 5113 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Acoustical panels.
 - 2. Metal suspension system.
- B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
- B. Samples: For each exposed product and for each color and texture specified, 6 inches in size.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For finishes to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same production run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.
 - 2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
- B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.6 FIELD CONDITIONS

- A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
 - 1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Source Limitations for Ceiling System: Obtain each type of acoustical ceiling panel and its supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: Class A in accordance with ASTM E1264.
 - 2. Smoke-Developed Index: 50 or less.
- B. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL or from the listings of another qualified testing agency.

2.3 ACOUSTICAL PANELS

- A. Acoustical Panels (ACP-1):
 - 1. Basis-of-Design: Subject to compliance with requirements, provide Armstrong School Zone; or a comparable product by one of the following:
 - a. USG Corporation
 - b. Armstrong Worldwide
 - c. Rockfon; ROCKWOOL International
 - 2. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.
 - 3. Classification: Provide fire-resistance-rated panels as follows:
 - a. Type and Form, Type III: Mineral base with painted finish; Form 2, water felted.
 - b. Pattern: D (fissured).
 - 4. Color: As indicated on drawings.
 - 5. Light Reflectance (LR): Not less than 0.82.
 - 6. Ceiling Attenuation Class (CAC): Not less than 35.
 - 7. Noise Reduction Coefficient (NRC): Not less than 0.70.
 - 8. Edge/Joint Detail: As indicated on Drawings.
 - 9. Thickness: As indicated on Drawings.

10. Modular Size: As indicated on drawings.
 11. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.
- B. Acoustical Panels (ACP-2):
1. Basis of Design: Subject to compliance with requirements, provide CertainTeed; Vinylrock or a comparable product by one of the following:
 - a. USG Corporation
 - b. Armstrong Worldwide
 - c. Rockfon; ROCKWOOL International
 2. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.
 3. Classification: Provide fire-resistance-rated panels as follows:
 - a. Type and Form, Type XX: High-density, ceramic- and mineral-base panels with scrubbable finish, resistant to heat, moisture, and corrosive fumes.
 - b. Pattern: G (smooth)
 4. Color: As indicated on Drawings
 5. Light Reflectance (LR): Not less than 0.78.
 6. Ceiling Attenuation Class (CAC): Not less than 34.
 7. Edge/Joint Detail: As indicated on Drawings.
 8. Thickness: As indicated on Drawings
 9. Modular Size: As indicated on Drawings

2.4 METAL SUSPENSION SYSTEM

- A. Exposed Metal Suspension System:
1. Basis-of-Design: Subject to compliance with requirements, provide Rockfon; ROCKWOOL International Chicago Metallic 200 Hook-Grid 15/16" or a comparable product by one of the following
 - a. Armstrong Ceiling & Wall Solutions
 - b. CertainTeed; SAINT-GOBAIN
 - c. USG Corporation
 2. Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, metal suspension system and accessories in accordance with ASTM C635/C635M and designated by type, structural classification, and finish indicated.
 3. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrolytically zinc coated, or hot-dip galvanized, G30 coating designation; with prefinished 15/16-inch- wide metal caps on flanges.
 - a. Structural Classification: Intermediate-duty system.
 - b. End Condition of Cross Runners: Override (stepped) type.
 - c. Face Design: Flat, flush.
 - d. Cap Material: Cold-rolled steel.
 - e. Cap Finish: Painted white.

2.5 ACCESSORIES

- A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.
- B. Wire Hangers, Braces, and Ties: Provide wires as follows:
 - 1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
 - 2. Stainless Steel Wire: ASTM A580/A580M, Type 304, nonmagnetic.
 - 3. Nickel-Copper-Alloy Wire: ASTM B164, nickel-copper-alloy UNS No. N04400.
 - 4. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.135-inch diameter wire.
- C. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.
- B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.
- B. Layout openings for penetrations centered on the penetrating items.

3.3 INSTALLATION OF ACOUSTICAL PANEL CEILINGS

- A. Install acoustical panel ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.
- B. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
 - 1. Do not use exposed fasteners, including pop rivets, on moldings and trim.

- C. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.
 - 1. Arrange directionally patterned acoustical panels as follows:
 - a. As indicated on reflected ceiling plans.
 - 2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.

3.4 CLEANING

- A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.
- B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION 09 5113

SECTION 09 6513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Thermoplastic rubber base.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
 - 2. Include manufacturer's written installation instructions for each type of substrate.
- B. Samples: For each exposed product and for each color and texture specified, not less than 3 inches long.
- C. Samples for Verification: For each type of exposed product indicated and for each color, texture, and pattern required in manufacturer's standard-size Samples, but not less than 12 inches long.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Furnish not less than 10 linear ft. for every or fraction thereof, of each type, color, pattern, and size of resilient product installed.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store resilient products and installation materials in dry spaces protected from the weather, with ambient temperatures maintained within range recommended by manufacturer, but not less than 50 deg F or more than 90 deg F.

1.5 FIELD CONDITIONS

- A. Maintain ambient temperatures within range recommended by manufacturer, but not less than 70 deg F or more than 95 deg F, in spaces to receive resilient products during the following periods:
 - 1. 48 hours before installation.
 - 2. During installation.
 - 3. 48 hours after installation.
- B. After installation and until Substantial Completion, maintain ambient temperatures within range recommended by manufacturer, but not less than 55 deg F or more than 95 deg F.

- C. Install resilient products after other finishing operations, including painting, have been completed.

PART 2 - PRODUCTS

2.1 RESILIENT BASE

- A. Thermoplastic Rubber Base:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexco Corporation
 - b. Roppe Corporation; Roppe Holding Company
 - c. Tarkett USA
 - 2. Classification: ASTM F1861, Type TP (rubber, thermoplastic), Group I (solid, homogeneous).
 - 3. Style and Location:
 - a. Style B, Cove: Refer to drawings.
 - 4. Thickness: 0.125 inch.
 - 5. Height: As indicated on Drawings.
 - 6. Lengths: Coils in manufacturer's standard length.
 - 7. Outside Corners: Preformed.
 - 8. Inside Corners: Job formed or preformed.
 - 9. Colors: As indicated on Drawings.

2.2 INSTALLATION MATERIALS

- A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.
- B. Adhesives: Water-resistant type recommended in writing by resilient-product manufacturer for resilient products and substrate conditions indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
 - 1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resilient products.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Installation of resilient products indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Prepare substrates in accordance with manufacturer's written instructions to ensure adhesion of resilient products.
- B. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.
- C. Do not install resilient products until materials are the same temperature as space where they are to be installed.
 - 1. At least 48 hours in advance of installation, move resilient products and installation materials into spaces where they will be installed.
- D. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

3.3 INSTALLATION OF RESILIENT BASE

- A. Comply with manufacturer's written instructions for installing resilient base.
- B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.
- C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.
- D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.
- E. Do not stretch resilient base during installation.
- F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.
- G. Preformed Corners: Install preformed corners before installing straight pieces.
- H. Job-Formed Corners:
 - 1. Outside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 6 inches in length.
 - a. Form without producing discoloration (whitening) at bends.
 - 2. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 6 inches in length.
 - a. Miter or cope corners to minimize open joints.

3.4 CLEANING AND PROTECTION

- A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

- B. Perform the following operations immediately after completing resilient-product installation:
 - 1. Remove adhesive and other blemishes from surfaces.
 - 2. Sweep and vacuum horizontal surfaces thoroughly.
 - 3. Damp-mop horizontal surfaces to remove marks and soil.
- C. Protect resilient products from mars, marks, indentations, and other damage from construction operations and placement of equipment and fixtures during remainder of construction period.
- D. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION 09 6513

SECTION 09 6816 - SHEET CARPETING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Tufted carpet.
- B. Related Requirements:
 - 1. Section 02 4119 "Selective Demolition" for removing existing floor coverings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include manufacturer's written data on physical characteristics, durability, and fade resistance.
 - 2. Include manufacturer's written installation recommendations for each type of substrate.
- B. Samples for Verification: Actual sample of finished products for each of the following products and for each color and texture required. Label each Sample with manufacturer's name, material description, color, pattern, and designation indicated on Drawings and in schedules.
 - 1. Carpet: 12-inch- square Sample.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For carpet. Include the following:
 - 1. Methods for maintaining carpet, including cleaning and stain-removal products and procedures and manufacturer's recommended maintenance schedule.
 - 2. Precautions for cleaning materials and methods that could be detrimental to carpet.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Carpet: Full-width rolls equal to 5 percent of amount installed for each type indicated, but not less than 10 sq. yd.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Comply with CRI 104.
- B. Deliver carpet in original mill protective covering with mill register numbers and tags attached.

1.6 FIELD CONDITIONS

- A. Comply with CRI 104 for temperature, humidity, and ventilation limitations.
- B. Environmental Limitations: Do not deliver or install carpet until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, and ambient temperature and humidity conditions are maintained at levels planned for building occupants during the remainder of the construction period.

1.7 WARRANTY

- A. Special Warranty for Carpet: Manufacturer agrees to repair or replace components of carpet installation that fail in materials or workmanship within specified warranty period.
 - 1. Warranty does not include deterioration or failure of carpet due to unusual traffic, failure of substrate, vandalism, or abuse.
 - 2. Failures include, but are not limited to, the following:
 - a. More than 10 percent loss of face fiber, edge raveling, snags, and runs.
 - b. Loss of tuft-bind strength.
 - c. Excess static discharge.
 - d. Delamination.
 - 3. Warranty Period: limited lifetime warranty from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 TUFTED CARPET**

- A. Basis of Design Product (CPT-1 and CPT-2): Subject to compliance with requirements, provide Tarkett USA; Powerbond or comparable product by one of the following:
 - 1. Interface, Inc.
 - 2. Milliken & Company
 - 3. Mohawk Carpet, LLC; The Mohawk Group
- B. Color: As indicated on Drawings.
- C. Pattern: As indicated on Drawings.
- D. Fiber Type: Solution dyed nylon
- E. Pile Characteristic: Level-loop pile.
- F. Stitches: No less than 9 stitches per inch.
- G. Face Weight: No less than 20 oz./sq. yd.
- H. Primary Backing: Manufacturer's standard material.
- I. Secondary Backing: Manufacturer's standard material.
- J. Roll Width: No less than 6 ft.

- K. Applied Treatments:
1. Applied Soil-Resistance Treatment: Manufacturer's standard material.
 2. Antimicrobial Treatment: Manufacturer's standard material.
 - a. Antimicrobial Activity: Not less than 2 mm halo of inhibition for gram-positive bacteria, not less than 1 mm halo of inhibition for gram-negative bacteria, and no fungal growth, in accordance with AATCC 174.

2.2 INSTALLATION ACCESSORIES

- A. Trowelable Leveling and Patching Compounds: Latex-modified, hydraulic-cement-based formulation provided or recommended in writing by carpet manufacturer.
- B. Adhesives: Water-resistant, mildew-resistant, nonstaining types to suit products and subfloor conditions indicated, that comply with flammability requirements for installed carpet and that are recommended in writing or provided by carpet manufacturer.
- C. Seam Adhesive: Hot-melt adhesive tape or similar product recommended in writing by carpet manufacturer for sealing and taping seams and butting cut edges at backing to form secure seams and to prevent pile loss at seams.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for maximum moisture content, alkalinity range, installation tolerances, and other conditions affecting carpet performance.
- B. Examine carpet for type, color, pattern, and potential defects.
- C. Concrete Slabs: Verify that finishes comply with requirements specified in Section 03 3000 "Cast-in-Place Concrete" and that surfaces are free of cracks, ridges, depressions, scale, and foreign deposits.
1. Moisture Testing: Perform tests so that each test area does not exceed 1000 sq. ft., and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. in 24 hours.
 - b. Relative Humidity Test: Using in situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
 - c. Perform additional moisture tests recommended in writing by adhesive, carpet cushion, and carpet manufacturers. Proceed with installation only after substrates pass testing.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Comply with CRI 104 and with carpet manufacturer's written installation instructions for preparing substrates.
- B. Use trowelable leveling and patching compounds, in accordance with manufacturer's written instructions, to fill cracks, holes, depressions, and protrusions in substrates. Fill or level cracks, holes and depressions 1/8 inch wide or wider, and protrusions more than 1/32 inch, unless more stringent requirements are required by manufacturer's written instructions.
- C. Concrete Substrates: Remove coatings, including curing compounds, and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, without using solvents. Use mechanical methods recommended in writing by adhesive and carpet manufacturers.
- D. Broom and vacuum clean substrates to be covered immediately before installing carpet.

3.3 INSTALLATION

- A. Comply with CRI 104 and carpet manufacturer's written installation instructions for the following:
 - 1. Preapplied adhesive installation.
- B. Maintain dye-lot integrity. Do not mix dye lots in same area.
- C. Comply with carpet manufacturer's written instructions and Shop Drawings for seam locations and direction of carpet; maintain uniformity of carpet direction and lay of pile. At doorways, center seams under the door in closed position.
- D. Install pattern parallel to walls and borders.
- E. Cut and fit carpet to butt tightly to vertical surfaces, permanent fixtures, and built-in furniture including cabinets, pipes, outlets, edgings, thresholds, and nosings. Bind or seal cut edges as recommended in writing by carpet manufacturer.
- F. Extend carpet into toe spaces, door reveals, closets, open-bottomed obstructions, removable flanges, alcoves, and similar openings.
- G. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on carpet as marked on subfloor. Use nonpermanent, nonstaining marking device.

3.4 CLEANING AND PROTECTION

- A. Perform the following operations immediately after installing carpet:
 - 1. Remove excess adhesive, seam sealer, and other surface blemishes using cleaner recommended in writing by carpet manufacturer.
 - 2. Remove yarns that protrude from carpet surface.

3. Vacuum carpet using commercial machine with face-beater element.
-
- B. Protect carpet against damage from construction operations and placement of equipment and fixtures during the remainder of construction period. Use protection methods indicated or recommended in writing by carpet manufacturer and carpet cushion manufacturer.

END OF SECTION 09 6816

SECTION 09 9124 - INTERIOR PAINTING (MPI STANDARDS)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Surface preparation of substrates and application of the following:
 - 1. Interior paint systems.
- B. Related Requirements:
 - 1. Section 05 5000 "Metal Fabrications" for shop priming metal fabrications.

1.2 DEFINITIONS

- A. MPI Gloss Level G1: Not more than 5 units at 60 degrees and 10 units at 85 degrees, in accordance with ASTM D523.
- B. MPI Gloss Level G2: Not more than 10 units at 60 degrees and between 10 to 35 units at 85 degrees, in accordance with ASTM D523.
- C. MPI Gloss Level G3: Between 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, in accordance with ASTM D523.
- D. MPI Gloss Level G4: Between 20 to 35 units at 60 degrees and not less than 35 units at 85 degrees, in accordance with ASTM D523.
- E. MPI Gloss Level G5: Between 35 to 70 units at 60 degrees, in accordance with ASTM D523.
- F. MPI Gloss Level G6: Between 70 to 85 units at 60 degrees, in accordance with ASTM D523.
- G. MPI Gloss Level G7: More than 85 units at 60 degrees, in accordance with ASTM D523.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 2. Include preparation requirements and application instructions.
 - 3. Indicate VOC content.
- B. Samples: For each type of topcoat product.
- C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat. Submit actual paint drawdowns as specified below for verification Samples.
 - 1. Submit Samples on rigid backing, 8 inches square.
 - 2. Apply coats on Samples in steps to show each coat required for system.

3. Label each coat of each Sample.
4. Label each Sample for location and application area.

- D. Product List: Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match paint products applied and that are packaged with protective covering for storage and identified with labels describing contents.
1. Paint Products: 5 percent, but not less than 1 gal. of each material and color applied.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
1. Maintain containers in clean condition, free of foreign materials and residue.
 2. Remove rags and waste from storage areas daily.

1.6 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F.
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures of less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each paint product from single source from single manufacturer.

2.2 INTERIOR PAINTS, GENERAL

- A. Interior Paint Systems: Subject to compliance with requirements, provide one of the products listed in the applicable interior painting schedule articles for the paint category indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Benjamin Moore & Co.
 - b. Sherwin-Williams Company (The)
- B. MPI Standards: Provide products complying with MPI standards indicated in applicable interior painting schedule articles and listed in the "MPI Approved Products List."

- C. Material Compatibility:
1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 2. For each coat in a paint system, products must be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.
- D. VOC Content: For field applications that are inside the weatherproofing system, verify paints and coatings comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
1. Flat Paints and Coatings: 50 g/L.
 2. Nonflat Paints and Coatings: 50 g/L.
 3. Primers, Sealers, and Undercoaters: 100 g/L.
 4. Rust-Preventive Coatings: 100 g/L.
 5. Zinc-Rich Industrial Maintenance Primers: 100 g/L.
 6. Pretreatment Wash Primers: 420 g/L.
 7. Floor Coatings: 50 g/L.
 8. Shellacs, Clear: 730 g/L.
 9. Shellacs, Pigmented: 550 g/L.
- E. Low-Emitting Materials: For field applications that are inside the weatherproofing system, verify 90 percent of paints and coatings comply with requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. Material Emissions and Pollutant Control: Verify not less than 85 percent of field-applied paints and coatings that are inside the weatherproofing system comply with either of the following:
1. Low-Emitting Materials: Verify VOC emissions comply with requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Verify formaldehyde emissions do not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 2. Verify VOC content does not exceed limits of authorities having jurisdiction and the following:
 - a. Flat Coatings: 50 g/L.
 - b. Nonflat Coatings: 100 g/L.
 - c. Nonflat - High-Gloss Coatings: 150 g/L.
 - d. Concrete/Masonry Sealers: 100 g/L.
 - e. Floor Coatings: 100 g/L.
 - f. Industrial Maintenance Coatings: 250 g/L.
 - g. Low-Solids Coatings: 120 g/L.
 - h. Mastic Texture Coatings: 100 g/L.
 - i. Metallic Pigmented Coatings: 500 g/L.
 - j. Pretreatment Wash Primers: 420 g/L.
 - k. Primers, Sealers, and Undercoaters: 100 g/L.
 - l. Reactive Penetrating Sealers: 350 g/L.
 - m. Recycled Coatings: 250 g/L.

n. Rust-Preventive Coatings: 250 g/L.

- G. VOC Emissions: For field applications inside the building, wall paints shall contain no more than half of the chronic REL of VOCs when tested according to the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- H. Colors: Match Architect's samples.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
1. Concrete: 12 percent.
 2. Cementitious Composition Board: 12 percent.
 3. Masonry (Clay and CMUs): 12 percent.
 4. Wood: 15 percent.
 5. Gypsum Board: 12 percent. Verify that finishing compound is dry and sanded smooth.
- C. Verify suitability of substrates, including surface conditions and compatibility, with finishes and primers. Proceed with coating application only after unsatisfactory conditions have been corrected.
1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces to be painted exceeds that permitted in manufacturer's written instructions.
- E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceeds that permitted in manufacturer's written instructions.
- F. Steel Substrates: Remove loose rust, loose mill scale, loose shop primer, and other loose foreign matter. Clean using methods recommended in writing by paint manufacturer but not less than the following:
 - 1. SSPC-SP 3.
- G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.
- H. Galvanized Metal Substrates: Remove grease and oil residue from galvanized metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.
- I. Aluminum Substrates: Remove loose surface oxidation.
- J. Wood Substrates:
 - 1. Scrape and clean knots. Before applying primer, apply coat of knot sealer recommended in writing by topcoat manufacturer for interior use in paint system indicated.
 - 2. Sand surfaces that will be exposed to view and remove sanding dust.
 - 3. Prime edges, ends, faces, undersides, and backsides of wood.
 - 4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.
- K. Canvas and Cotton Insulation Covering Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.
- L. Plastic Trim Fabrication Substrates: Remove dust, dirt, and other foreign material that might impair bond of paints to substrates.

3.3 APPLICATION OF INTERIOR PAINT PRODUCTS

- A. Apply paints in accordance with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
 - 1. Use applicators and techniques suited for paint and substrate indicated.

2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 5. Primers specified in applicable interior painting schedule articles may be omitted on items that are factory primed or factory finished if compatible with intermediate and topcoat coatings and acceptable to intermediate and topcoat paint manufacturers.
- B. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

3.4 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.
1. Touch up and restore painted surfaces damaged by testing. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.
 2. Cost of retesting is Contractor's responsibility.

3.5 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
1. Do not clean equipment with free-draining water and prevent solvents, thinners, cleaners, and other contaminants from entering into waterways, sanitary and storm drain systems, and ground.
 2. Dispose of contaminants in accordance with requirements of authorities having jurisdiction.
 3. Allow empty paint cans to dry before disposal.
 4. Collect waste paint by type and deliver to recycling or collection facility.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.6 INTERIOR PAINTING SCHEDULE, MASONRY SUBSTRATES

- A. CMU Substrates:
 - 1. Latex System: MPI INT 4.2A.
 - a. Prime Coat: Block filler, latex, interior/exterior, MPI #4.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, (MPI Gloss Level G3), MPI #52.

3.7 INTERIOR PAINTING SCHEDULE, METAL SUBSTRATES

- A. Steel and Iron Substrates:
 - 1. High-Performance Architectural Latex System:
 - a. Prime Coat: Primer, alkyd, quick dry, for metal, MPI #76.
 - b. Intermediate Coat: Latex, interior, high-performance architectural, matching topcoat.
 - c. Topcoat: Latex, interior, high-performance architectural, semigloss (MPI Gloss Level G5), MPI #141.
- B. Galvanized Metal Substrates:
 - 1. Institutional Low-Odor/VOC Latex System: MPI INT 5.3N.
 - a. Prime Coat: Primer, galvanized, water based, MPI #134.
 - b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
 - c. Topcoat: Latex, interior, institutional low odor/VOC, semigloss (MPI Gloss Level G5), MPI #147.
- C. Aluminum (Not Anodized or Otherwise Coated) Substrates:
 - 1. Latex System: MPI INT 5.4H.
 - a. Prime Coat: Primer, quick dry, for aluminum, MPI #95.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, semigloss (MPI Gloss Level G5), MPI #54.
- D. Stainless Steel Substrates:
 - 1. Latex System: MPI INT 5.6H.
 - a. Prime Coat: Primer, bonding, solvent based, MPI #69.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, semigloss (MPI Gloss Level G5), MPI #54.

3.8 INTERIOR PAINTING SCHEDULE, GYPSUM-BASED SUBSTRATES

- A. Gypsum Board and Plaster Substrates:
 - 1. Latex over Latex Sealer System: MPI INT 9.2A.
 - a. Prime Coat: Primer sealer, latex, interior, MPI #50.
 - b. Intermediate Coat: Latex, interior, matching topcoat.
 - c. Topcoat: Latex, interior, (MPI Gloss Level G3), MPI #52.
 - d. Topcoat: Latex, interior, flat (MPI Gloss Level G1), MPI #53.

END OF SECTION 09 9124

SECTION 09 9301 - STAINING AND TRANSPARENT FINISHING (MPI STANDARDS)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Staining and transparent finishing of exterior and interior wood surfaces.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - 2. Include preparation requirements and application instructions.
 - 3. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 4. Indicate VOC content.
- B. Samples for Verification: For each type of finish system and in each color and gloss of finish required.
 - 1. Submit Samples on representative samples of actual wood substrates, 8 inches long.
 - 2. Apply coats on Samples in steps to show each coat required for system.
 - 3. Label each coat of each Sample.
 - 4. Label each Sample for location and application area.
- C. Product List: Cross-reference to finish system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.
- D. Sustainable Design Submittals:
 - 1. Third-Party Certifications: For each product.
 - 2. Third-Party Certified Life Cycle Assessment: For each product.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same product run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Stains and Transparent Finishes: 5 percent, but not less than 1 gal. of each material and color applied.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.5 FIELD CONDITIONS

- A. Apply finishes only when temperature of surfaces to be finished and ambient air temperatures are between 50 and 95 deg F.
- B. Do not apply finishes when relative humidity exceeds 85 percent, at temperatures of less than 5 deg F above the dew point, or to damp or wet surfaces.
- C. Do not apply exterior finishes in snow, rain, fog, or mist.

PART 2 - PRODUCTS**2.1 STAINING AND TRANSPARENT FINISHING (MPI STANDARDS)**

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Behr Paint Company (Behr Process LLC)
 - 2. Benjamin Moore & Co.
 - 3. PPG Paints; PPG Industries, Inc.
 - 4. Sherwin-Williams Company (The)

2.2 SOURCE LIMITATIONS

- A. Source Limitations: Obtain each coating product from single source from single manufacturer.

2.3 MATERIALS, GENERAL

- A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products List."
- B. Material Compatibility:
 - 1. Materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. Clear Wood Finishes, Varnishes: 350 g/L.
 - 3. Clear Wood Finishes, Lacquers: 550 g/L.
 - 4. Shellacs, Clear: 730 g/L.
 - 5. Stains: 250 g/L.
 - 6. Primers, Sealers, and Undercoaters: 100 g/L.
 - 7. Clear Wood Finishes, Varnishes: 275 g/L.
 - 8. Clear Wood Finishes, Lacquers: 275 g/L.
 - 9. Shellacs, Clear: 730 g/L.
 - 10. Stains: 100 g/L.
 - 11. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.

12. Low-Emitting Materials: VOC emissions shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
13. VOC content shall not exceed limits of authorities having jurisdiction and the following:
 - a. Shellacs, Clear: 730 g/L.
 - b. Stains: 250 g/L.
 - c. Clear Wood Finishes (Varnishes, Sanding Sealers, and Lacquers): 275 g/L.

C. Stain Colors: Match Architect's samples.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Exterior Wood Substrates: 15 percent, when measured with an electronic moisture meter.
- C. Maximum Moisture Content of Interior Wood Substrates: 13 percent, when measured with an electronic moisture meter.
- D. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers.
- E. Proceed with finish application only after unsatisfactory conditions have been corrected.
 1. Beginning finish application constitutes Contractor's acceptance of substrates and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and finishing.
 1. After completing finishing operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean and prepare surfaces to be finished according to manufacturer's written instructions for each substrate condition and as specified.
 1. Remove dust, dirt, oil, and grease by washing with a detergent solution; rinse thoroughly with clean water and allow to dry. Remove grade stamps and pencil marks by sanding lightly. Remove loose wood fibers by brushing.

2. Remove mildew by scrubbing with a commercial wash formulated for mildew removal and as recommended by stain manufacturer.
- D. Interior Wood Substrates:
1. Scrape and clean knots, and apply coat of knot sealer before applying primer.
 2. Apply wood filler paste to open-grain woods, as defined in "MPI Architectural Painting Specification Manual," to produce smooth, glasslike finish.
 3. Sand surfaces exposed to view and dust off.
 4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dry.

3.3 APPLICATION

- A. Apply finishes according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
1. Use applicators and techniques suited for finish and substrate indicated.
 2. Finish surfaces behind movable equipment and furniture same as similar exposed surfaces.
 3. Do not apply finishes over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
- B. Apply finishes to produce surface films without cloudiness, holidays, lap marks, brush marks, runs, ropiness, or other surface imperfections.

3.4 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing finish application, clean spattered surfaces. Remove spattered materials by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from finish application. Correct damage by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced finished wood surfaces.

3.5 INTERIOR WOOD -FINISH-SYSTEM SCHEDULE

- A. Wood Substrates, Wood Trim and Architectural Woodwork:
1. Water-Based Varnish over Stain System:
 - a. Stain Coat: Stain, semitransparent, for interior wood.
 - b. First Intermediate Coat: Water-based varnish matching topcoat.
 - c. Second Intermediate Coat: Water-based varnish matching topcoat.
 - d. Topcoat, Satin: Varnish, water based, clear (MPI Gloss Level 4).
 - e. Topcoat, Semigloss: Varnish, water based, clear (MPI Gloss Level 5).

END OF SECTION 09 9301

SECTION 10 1100 - VISUAL DISPLAY UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Visual display board assemblies.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Visual display board assemblies.
- B. Product Data Submittals: For each product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, finishes, and accessories for visual display units.
- C. Samples for Initial Selection: For each type of visual display unit indicated, for units with factory-applied color finishes, and as follows:
 - 1. Samples of facings for each visual display panel type, indicating color and texture.
- D. Samples for Verification: For each type of visual display unit indicated.
 - 1. Visual Display Panel: Not less than 3 inches by 3 inches, with facing, core, and backing indicated for final Work. Include one panel for each type, color, and texture required.
 - 2. Trim: 6-inch- long sections of each trim profile.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For visual display units to include in maintenance manuals.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver factory-fabricated visual display units completely assembled in one piece. If dimensions exceed maximum manufactured unit size, or if unit size is impracticable to ship in one piece, provide two or more pieces with joints in locations indicated on approved Shop Drawings.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Do not deliver or install visual display units until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.

2.2 VISUAL DISPLAY BOARD ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CIG JAN Products, Ltd.
 - 2. Marsh Industries, Inc.
 - 3. PolyVision Corporation
- B. Visual Display Board Assembly: factory fabricated.
 - 1. Assembly: tackboard.
 - 2. Corners: Square.
 - 3. Width: As indicated on Drawings.
 - 4. Height: As indicated on Drawings.
 - 5. Mounting Method: Direct to wall.
- C. Tackboard Panel: Homogenous tackable cork/linoleum tackboard panel on core indicated.
- D. Aluminum Frames and Trim: Fabricated from not less than 0.062-inch- thick, extruded aluminum; standard size and shape.
 - 1. Aluminum Finish: Clear anodic finish.

2.3 MATERIALS

- A. Plastic-Impregnated-Cork Sheet: Seamless, homogeneous, self-sealing sheet consisting of granulated cork, linseed oil, resin binders, and dry pigments that are mixed and calendared onto fabric backing; with washable vinyl finish and integral color throughout; with surface-burning characteristics indicated.
- B. Hardboard: ANSI A135.4, tempered.
- C. Particleboard: ANSI A208.1, Grade M-1.
- D. MDF: ANSI A208.2, Grade 130.
- E. Fiberboard: ASTM C208 cellulosic fiber insulating board.
- F. Extruded Aluminum: ASTM B221, Alloy 6063.

- G. Adhesives for Field Application: Mildew-resistant, nonstaining adhesive for use with specific type of panels, sheets, or assemblies; and for substrate application; as recommended in writing by visual display unit manufacturer.

2.4 GENERAL FINISH REQUIREMENTS

- A. Comply with NAAMM/NOMMA AMP 500 for recommendations for applying and designating finishes.
- B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.5 ALUMINUM FINISHES

- A. Clear Anodic Finish: AAMA 611, AA-M12C22A31, Class II, 0.010 mm or thicker.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, surface conditions of wall, and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical power systems to verify actual locations of connections before installation of motorized, sliding visual display units.
- C. Examine walls and partitions for proper preparation and backing for visual display units.
- D. Examine walls and partitions for suitable framing depth where sliding visual display units will be installed.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions for surface preparation.
- B. Clean substrates of substances, such as dirt, mold, and mildew, that could impair the performance of and affect the smooth, finished surfaces of visual display boards.
- C. Prepare surfaces to achieve a smooth, dry, clean surface free of flaking, unsound coatings, cracks, defects, projections, depressions, and substances that will impair bond between visual display units and wall surfaces.

3.3 INSTALLATION

- A. General: Install visual display surfaces in locations and at mounting heights indicated on Drawings, or if not indicated, at heights indicated below. Keep perimeter lines straight, level, and plumb. Provide grounds, clips, backing materials, adhesives, brackets, anchors, trim, and accessories necessary for complete installation.
- B. Factory-Fabricated Visual Display Board Assemblies:
 - 1. Attach concealed clips, hangers, and grounds to wall surfaces and to visual display board assemblies with fasteners at not more than 16 inches o.c. Secure tops and bottoms of boards to walls.

3.4 CLEANING AND PROTECTION

- A. Clean visual display units in accordance with manufacturer's written instructions. Attach one removable cleaning instructions label to visual display unit in each room.
- B. Touch up factory-applied finishes to restore damaged or soiled areas.
- C. Cover and protect visual display units after installation and cleaning.

END OF SECTION 10 1100

SECTION 10 1423.16 - ROOM-IDENTIFICATION PANEL SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes room-identification signs that are directly attached to the building.

1.2 DEFINITIONS

- A. Accessible: In accordance with the accessibility standard.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For room-identification signs.
 - 1. Include fabrication and installation details and attachments to other work.
 - 2. Show sign mounting heights, locations of supplementary supports to be provided by other installers, and accessories.
 - 3. Show message list, typestyles, graphic elements, including raised characters and Braille, and layout for each sign at least half size.
- C. Samples for Verification: For each type of sign assembly showing all components and with the required finish(es), in manufacturer's standard size unless otherwise indicated and as follows:
 - 1. Room-Identification Signs: Full-size Sample.
 - 2. Full-size Samples, if approved, will be returned to Contractor for use in Project.
- D. Product Schedule: For room-identification signs. Use same designations indicated on Drawings or specified.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For signs to include in maintenance manuals.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of signs that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Deterioration of finishes beyond normal weathering.
 - b. Deterioration of embedded graphic image.
 - c. Separation or delamination of sheet materials and components.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design".

2.2 ROOM-IDENTIFICATION SIGNS

- A. Room-Identification Sign: Sign system with smooth, uniform surfaces; with message and characters having uniform faces, sharp corners, and precisely formed lines and profiles; and as follows:
 - 1. Laminated-Sheet Sign: Acrylic face sheet with raised graphics laminated to acrylic backing sheet to produce composite sheet.
 - a. Composite-Sheet Thickness: 0.125 inch.
 - b. Color(s): As selected by Architect from manufacturer's full range.
 - 2. Sign-Panel Perimeter: Finish edges smooth.
 - a. Edge Condition at Vertical Edges: Square cut.
 - b. Corner Condition in Elevation: Square.
 - 3. Mounting: Surface mounted to wall with two-face tape.
 - 4. Text and Typeface: Accessible raised characters and Braille. Finish raised characters to contrast with background color, and finish Braille to match background color.

2.3 SIGN MATERIALS

- A. Acrylic Sheet: ASTM D4802, category as standard with manufacturer for each sign, Type UVF (UV filtering).
- B. Vinyl Film: UV-resistant vinyl film with pressure-sensitive, permanent adhesive; die cut to form characters or images as indicated on Drawings.

2.4 ACCESSORIES

- A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of signs, noncorrosive and compatible with each material joined, and complying with the following:
 - 1. Use concealed fasteners and anchors unless indicated to be exposed.
- B. Adhesive: As recommended by sign manufacturer.
- C. Two-Face Tape: Manufacturer's standard high-bond, foam-core tape, 0.045 inch thick, with adhesive on both sides.

2.5 FABRICATION

- A. General: Provide manufacturer's standard sign assemblies according to requirements indicated.
 - 1. Preassemble signs and assemblies in the shop to greatest extent possible. Disassemble signs and assemblies only as necessary for shipping and handling limitations. Clearly mark units for reassembly and installation; apply markings in locations concealed from view after final assembly.
 - 2. Mill joints to a tight, hairline fit. Form assemblies and joints exposed to weather to resist water penetration and retention.
 - 3. Conceal connections if possible; otherwise, locate connections where they are inconspicuous.
 - 4. Provide rabbets, lugs, and tabs necessary to assemble components and to attach to existing work. Drill and tap for required fasteners. Use concealed fasteners where possible; use exposed fasteners that match sign finish.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Install signs using mounting methods indicated and according to manufacturer's written instructions.
 - 1. Install signs level, plumb, true to line, and at locations and heights indicated, with sign surfaces free of distortion and other defects in appearance.
 - 2. Install signs so they do not protrude or obstruct according to the accessibility standard.
 - 3. Before installation, verify that sign surfaces are clean and free of materials or debris that would impair installation.
- B. Accessibility: Install signs in locations on walls as indicated on Drawings.
- C. Mounting Methods:
 - 1. Two-Face Tape: Clean bond-breaking materials from substrate surface and remove loose debris. Apply tape strips symmetrically to back of sign and of suitable quantity to support weight of sign without slippage. Keep strips away from edges to prevent visibility at sign edges. Place sign in position, and push to engage tape adhesive.

3.2 ADJUSTING AND CLEANING

- A. Remove and replace damaged or deformed signs and signs that do not comply with specified requirements. Replace signs with damaged or deteriorated finishes or components that cannot be successfully repaired by finish touchup or similar minor repair procedures.
- B. Remove temporary protective coverings and strippable films as signs are installed.

- C. On completion of installation, clean exposed surfaces of signs according to manufacturer's written instructions, and touch up minor nicks and abrasions in finish. Maintain signs in a clean condition during construction and protect from damage until acceptance by Owner.

END OF SECTION 10 1423.16

SECTION 10 2600 - WALL AND DOOR PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Corner guards.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, impact strength, dimensions of individual components and profiles, and finishes.
 - 2. Include fire ratings of units recessed in fire-rated walls and listings for door-protection items attached to fire-rated doors.
- B. Samples for Verification: For each type of exposed finish on the following products, prepared on Samples of size indicated below:
 - 1. Corner Guards: 6 inches long.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For each type of wall and door protection product to include in maintenance manuals.
 - 1. Include recommended methods and frequency of maintenance for maintaining best condition of stainless-steel under anticipated traffic and use conditions. Include precautions against using cleaning materials and methods that may be detrimental to finishes and performance.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Corner-Guard: Full-size of maximum length equal to 2 percent of each type, color, and texture of cover installed, but no fewer than two, 48-inch- long units.
 - 2. Mounting and Accessory Components: Amounts proportional to the quantities of extra materials. Package mounting and accessory components with each extra material.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store wall and door protection in original undamaged packages and containers inside well-ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.
 - 1. Maintain room temperature within storage area at not less than 70 deg F during the period plastic materials are stored.
 - 2. Keep plastic materials out of direct sunlight.
 - 3. Store plastic wall- and door-protection components for a minimum of 72 hours, or until plastic material attains a minimum room temperature of 70 deg F.
 - a. Store corner-guard covers in a vertical position.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of wall- and door-protection units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including detachment of components from each other or from the substrates, delamination, and permanent deformation beyond normal use.
 - b. Deterioration of metals, metal finishes, plastics, and other materials beyond normal use.
 - 2. Warranty Period: Limited lifetime warranty from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 SOURCE LIMITATIONS**

- A. Obtain wall- and door-protection products from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Surface Burning Characteristics: Comply with ASTM E84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 450 or less.
- B. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1.

2.3 CORNER GUARDS

- A. Surface-Mounted, Metal Corner Guards: Fabricated as one piece from formed or extruded metal with formed edges; with 90- or 135-degree turn to match wall condition.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Babcock-Davis
 - b. Construction Specialties, Inc.
 - c. inpro Corporation
 - 2. Material:
 - a. Stainless-steel sheet, Type 430.
 - 1) Thickness: Minimum 16 gauge.
 - 2) Finish: Directional satin, No. 4.
 - 3. Wing Size: Nominal 2 by 2 inches or 2-1/2 by 2-1/2 inches.
 - 4. Corner Radius: 1/8 inch.
 - 5. Mounting: Adhesive.

2.4 MATERIALS

- A. Adhesive: As recommended by protection product manufacturer.

2.5 FABRICATION

- A. Fabricate wall and door protection according to requirements indicated for design, performance, dimensions, and member sizes, including thicknesses of components.
- B. Factory Assembly: Assemble components in factory to greatest extent possible to minimize field assembly. Disassemble only as necessary for shipping and handling.
- C. Quality: Fabricate components with uniformly tight seams and joints and with exposed edges rolled. Provide surfaces free of wrinkles, chips, dents, uneven coloration, and other imperfections. Fabricate members and fittings to produce flush, smooth, and rigid hairline joints.

2.6 FINISHES

- A. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and wall areas, with Installer present, for compliance with requirements for installation tolerances, fire rating, and other conditions affecting performance of the Work.
- B. Examine walls to which wall and door protection will be attached for blocking, grounds, and other solid backing that have been installed in the locations required for secure attachment of support fasteners.
 - 1. For wall and door protection attached with adhesive, verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Complete finishing operations, including painting, before installing wall and door protection.
- B. Before installation, clean substrate to remove dust, debris, and loose particles.

3.3 INSTALLATION

- A. Installation Quality: Install wall and door protection according to manufacturer's written instructions, level, plumb, and true to line without distortions. Do not use materials with chips, cracks, voids, stains, or other defects that might be visible in the finished Work.
- B. Mounting Heights: Install wall and door protection in locations and at mounting heights indicated on Drawings.
- C. Accessories: Provide splices, mounting hardware, anchors, trim, joint moldings, and other accessories required for a complete installation.

3.4 CLEANING

- A. Immediately after completion of installation, clean stainless-steel with manufacturer's recommended cleaners and methods.
- B. Remove excess adhesive using methods and materials recommended in writing by manufacturer.

END OF SECTION 10 2600

SECTION 10 2800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Public-use washroom accessories.
- B. Related Requirements:
 - 1. Section 09 3013 "Ceramic Tiling" for ceramic toilet and bath accessories.
- C. Owner provided, Contractor installed items include:
 - 1. Paper towel dispensers and trash.
 - 2. Soap dispensers.
 - 3. Toilet Paper Dispenser—Acclaim – Micro-Twin 521-02 grey/grey black – By Fort Howard.
 - 4. Electric hand dryer - "Pinnacle Hand Dryer"
 - a. Recessed Mounted - Model #PDC-R10
 - b. Surface Mounted - Model # P3-12S

1.2 COORDINATION

- A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.
- B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.3 ACTION SUBMITTALS

- A. Product Data: For each product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
- B. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.
 - 1. Identify locations using room designations indicated.
- C. Delegated Design Submittals: For grab bars.
 - 1. Include structural design calculations indicating compliance with specified structural-performance requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For accessories to include in maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, visible silver spoilage defects.
 - 2. Warranty Period: 10 years from date of Substantial Completion.
- B. Manufacturer's Special Warranty for Hand Dryers: Manufacturer agrees to repair or replace hand dryers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Design accessories and fasteners to comply with the following requirements:
 - 1. Grab Bars: Installed units are able to resist 250 lbf concentrated load applied in any direction and at any point.

2.2 MANUFACTURERS

- A. Source Limitations: Obtain public-use washroom accessories from single source from single manufacturer.
- B. Manufacturers: Provide products from one of the following:
 - 1. American Specialties, Inc, (ASI).
 - 2. Bobrick Washroom Equipment, Inc.
 - 3. Bradley Corporation.
 - 4. Approved Equivalent

2.3 PUBLIC-USE WASHROOM ACCESSORIES

- A. Grab Bar:
 - 1. Mounting: Flanges with concealed fasteners.
 - 2. Material: Stainless steel, 0.05 inch thick.
 - a. Finish: Smooth, ASTM A480/A480M No. 4 finish (satin).
 - 3. OD: 1-1/2 inches.
 - 4. Configuration and Length: As indicated on Drawings.
- B. Mirror Unit:
 - 1. Frame: Stainless steel angle, 0.05 inch thick.
 - a. Corners: Manufacturer's standard.
 - 2. Size: As indicated on Drawings.
- C. Hook:
 - 1. Description: Double-prong unit.
 - 2. Mounting: Concealed.
 - 3. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).

2.4 MATERIALS

- A. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.031-inch- minimum nominal thickness unless otherwise indicated.
- B. Steel Sheet: ASTM A1008/A1008M, Designation CS (cold rolled, commercial steel), 0.036-inch- minimum nominal thickness.
- C. Galvanized-Steel Sheet: ASTM A653/A653M, with G60 hot-dip zinc coating.
- D. Galvanized-Steel Mounting Devices: ASTM A153/A153M, hot-dip galvanized after fabrication.
- E. Fasteners: Screws, bolts, and other devices of same material as accessory unit, unless otherwise recommended by manufacturer or specified in this Section, and tamper and theft resistant where exposed, and of stainless or galvanized steel where concealed.
- F. Chrome Plating: ASTM B456, Service Condition Number SC 2 (moderate service).
- G. Mirrors: ASTM C1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.5 FABRICATION

- A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.
- B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION**3.1 INSTALLATION OF TOILET, BATH, AND LAUNDRY ACCESSORIES**

- A. Install accessories in accordance with manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
 - 1. Remove temporary labels and protective coatings.
- B. Grab Bars: Install to comply with specified structural-performance requirements.

3.2 ADJUSTING AND CLEANING

- A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.
- B. Clean and polish exposed surfaces in accordance with manufacturer's written instructions.

END OF SECTION 10 2800

SECTION 10 5123 - PLASTIC-LAMINATE-CLAD LOCKERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Plastic-laminate-clad wood lockers.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Plastic-laminate-clad wood lockers.
 - 2. Locker benches.
- B. Product Data Submittals: For each product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of locker.
- C. Shop Drawings: For plastic-laminate-clad wood lockers.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Show details full size.
 - 3. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
 - 4. Show locations and sizes of cutouts and holes for items installed in lockers.
 - 5. Show locker fillers, trim, base, sloping tops, and accessories.
 - 6. Show locker identification system and numbering sequence.
- D. Samples for Verification: For the following products:
 - 1. Plastic-laminate-clad panels, not less than 8 by 10 inches, for each type, color, pattern, and surface finish.
 - 2. Exposed cabinet hardware and accessories, one unit for each type and finish.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data

1.5 QUALITY ASSURANCE

- A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build mockup of typical locker, as shown on Drawings.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver lockers until painting and similar operations that could damage lockers have been completed in installation areas. If lockers must be stored in other-than-installation areas, store only in areas where environmental conditions are the same as those in final installation location, and comply with requirements specified in "Field Conditions" Article.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Do not deliver or install lockers until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F and relative humidity between 25 and 55 percent during the remainder of the construction period.
- B. Field Measurements: Where lockers are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings.
 1. Locate concealed framing, blocking, and reinforcements that support lockers by field measurements before being enclosed, and indicate measurements on Shop Drawings.
- C. Established Dimensions: Where lockers are indicated to fit to other construction, establish dimensions for areas where lockers are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

1.8 COORDINATION

- A. Coordinate sizes and locations of concealed wood support bases.
 1. Requirements are specified in Section 06 1000 "Rough Carpentry."
- B. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of work specified in other Sections to ensure that lockers can be supported and installed as indicated.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of lockers that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation of locks or hardware.
 - c. Deterioration of wood, finishes, and other materials beyond normal use.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Accessibility Standard: For lockers indicated to be accessible, comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1.

2.2 PLASTIC-LAMINATE-CLAD WOOD LOCKERS

- A. Locker Body: Fabricated from particleboard-core panels covered on both sides with thermally fused laminate overlay.
 1. Side Panels: 3/4 inch thick.
 2. Back Panel: 3/4 inch thick.
 3. Top Panel: 3/4 inch thick.
 4. Bottom Panel: 3/4 inch thick.
 5. Exposed Panel Edges: 3-mm-thick PVC to match panels.
- B. End Panels: Match style, material, construction, and finish of plastic-laminate.
- C. Shelves: Fabricated from particleboard-core panels covered on both sides with thermally fused laminate overlay; fixed.
 1. Thickness: 3/4 inch.
 2. Exposed Edges: 3-mm-thick PVC to match panels.
- D. Corners and Filler Panels: 3/4-inch- thick panels. Match style, material, construction, and finish of plastic-laminate.
- E. Plastic-Laminate Colors, Patterns, and Finishes:
 1. As indicated on Drawings.

2.3 MATERIALS

- A. Composite Wood: Provide materials that comply with requirements of referenced quality standard for each type of woodwork and quality grade specified unless otherwise indicated.
 1. Thermally Fused Laminate (TFL) Panels: Particleboard or medium-density fiberboard finished with thermally fused, melamine-impregnated decorative paper.
 2. Particleboard: ANSI A208.1, Grade M-2.
- B. High-Pressure Decorative Laminate: ISO 4586-3, grades as follows:
 1. Horizontal Surfaces: Grade HGS.
 2. Postformed Surfaces: Grade HGP.
 3. Vertical Surfaces: Grade VGS.

- C. **Fire-Retardant-Treated Materials:** Where fire-retardant-treated materials are indicated, use materials impregnated with fire-retardant chemical formulations indicated by a pressure process or other means acceptable to authorities having jurisdiction to produce products with fire-test-response characteristics specified.
1. Do not use material that is warped, discolored, or otherwise defective.
 2. Use fire-retardant-treatment formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants in solution to distinguish treated material from untreated material.
 3. **Fire-Retardant Particleboard:** Panels made from softwood particles and fire-retardant chemicals mixed together at time of panel manufacture to achieve flame-spread index of 25 or less and smoke-developed index of 25 or less according to ASTM E84:
 - a. Panels 3/4 Inch (19 mm) Thick and Less: ANSI A208.1, Grade M-2, except for the following minimum properties: density, 45 lb/cu. ft.; modulus of rupture, 1600 psi; modulus of elasticity, 300,000 psi; internal bond, 80 psi; and screw-holding capacity on face and edge, 250 and 225 lbf, respectively.
 - b. Panels 13/16 to 1-1/4 Inches (20 to 32 mm) Thick: ANSI A208.1, Grade M-1, except for the following minimum properties: density, 44 lb/cu. ft.; modulus of rupture, 1300 psi; modulus of elasticity, 250,000 psi; linear expansion, 0.50 percent; and screw-holding capacity on face and edge, 250 and 175 lbf, respectively.
- D. **Furring, Blocking, Shims, and Hanging Strips:** Softwood or hardwood lumber, kiln dried to less than 15 percent moisture content.
- E. **Anchors:** Material, type, size, and finish as required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.

2.4 HARDWARE

- A. **Hooks:** Manufacturer's standard, ball-pointed aluminum or steel; satin finish. Attach hooks with at least two fasteners.
1. Provide hooks as indicated on Drawings.

2.5 FABRICATION

- A. Fabricate each locker with shelves, an individual top, a bottom, and a back, and with common intermediate uprights separating compartments.
1. Fabricate lockers to dimensions, profiles, and details indicated.
 2. Ease edges of corners of solid-wood members to 1/16-inch radius.

- B. Fabricate lockers square, rigid, without warp, and with finished faces flat and free of dents, scratches, and chips. Accurately factory machine components for attachments. Make joints tight and true.
 - 1. Fabricate lockers with joints that are dadoed or rabbeted, glued full length, and stapled. Dado side panels to receive shelving except where indicated to be adjustable.
- C. Accessible Lockers: Fabricate as follows:
 - 1. Locate bottom shelf no lower than 15 inches above the floor.
 - 2. Where hooks, coat rods, or additional shelves are provided, locate no higher than 48 inches above the floor.
- D. Complete fabrication, including assembly, finishing, and hardware application, to maximum extent possible, before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 - 1. Trial fit assemblies at fabrication shop that cannot be shipped completely assembled. Install dowels, screws, bolted connectors, and other fastening devices that can be removed after trial fitting. Verify that the parts fit as intended, and check measurements of assemblies against field measurements indicated on Shop Drawings before disassembling for shipment.
 - 2. Use only manufacturer's nuts, bolts, screws, and other devices for assembly.
- E. Shop cut openings, to maximum extent possible, to receive hardware, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.
- F. Attach PVC edging to panels by thermally fusing edging to panels after panel fabrication.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine walls and floors or support bases, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Verify that furring is attached to concrete and masonry walls that are to receive lockers.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Condition lockers to average prevailing humidity conditions in installation areas before installation.

- B. Before installing lockers, examine factory-fabricated work for completeness and complete work as required, including removal of packing.

3.3 INSTALLATION

- A. Install lockers level, plumb, and true; use concealed shims.
- B. Connect groups of lockers together with manufacturer's standard zinc-plated steel fasteners, through predrilled holes, with no exposed fasteners on face frames. Fit lockers accurately together to form flush, tight, hairline joints.
- C. Install lockers without distortion so doors and drawers fit openings properly and are accurately aligned. Adjust hardware to center doors and drawers in openings, providing unencumbered operation. Complete installation of hardware and accessory items as indicated.
 - 1. Installation Tolerance: No more than 1/8 inch in 96-inch sag, bow, or other variation from a straight line. Shim as required with concealed shims.
- D. Locker Anchorage:
 - 1. Fasten lockers through back, near top and bottom, at ends with No. 8 pan- or bugle-head wood screws sized for 1-inch penetration into wood framing, blocking, or furring and spaced not more than 16 inches o.c.
- E. Scribe and cut corner and filler panels to fit adjoining work using fasteners concealed where practical. Repair damaged finish at cuts.

3.4 ADJUSTING

- A. Clean, lubricate, and adjust hardware.

3.5 PROTECTION

- A. Protect lockers from damage, abuse, dust, dirt, stain, or paint. Do not permit use during construction.
- B. Touch up marred finishes, or replace lockers that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by locker manufacturer.

END OF SECTION 10 5123

SECTION 12 3216 - MANUFACTURED PLASTIC-LAMINATE-CLAD CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Plastic-laminate-clad casework.
 - 2. Hardware and accessories.
- B. Related Requirements:
 - 1. Section 09 6513 "Resilient Base and Accessories" for resilient base applied to plastic-laminate-clad casework.
 - 2. Section 12 3623.13 "Plastic-Laminate-Clad Countertops."

1.2 DEFINITIONS

- A. Definitions in the AWI/AWMAC/VI's "Architectural Woodwork Standards" apply to the Work of this Section.

1.3 COORDINATION

- A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to ensure that casework can be supported and installed as indicated.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Plastic-laminate-clad casework.
 - 2. Hardware and accessories.
- B. Shop Drawings: For plastic-laminate-clad casework.
 - 1. Include plans, elevations, sections, and attachments to other work including blocking and reinforcements required for installation.
 - 2. Indicate types and sizes of casework.
 - 3. Indicate manufacturer's catalog numbers for casework.
 - 4. Show fabrication details, including types and locations of hardware.
 - 5. Indicate locations of and clearances from adjacent walls, doors, windows, other building components, and equipment.
 - 6. Apply AWI's Quality Certification Program label to Shop Drawings.
- C. Samples for Verification: For the following:
 - 1. Plastic Laminates: 3 by 5 inches for each type, color, pattern, and surface finish required.
 - a. Provide one Sample applied to core material with specified edge material applied to one edge.
 - 2. Edge Band: 6 inches, for each type, color, pattern, and surface finish required.
 - 3. Cubby: One full-size, finished cubby complete with hardware and shelves.

4. Full-Size Samples: Maintain at Project site during construction in an undisturbed condition as a standard for judging the completed Work. Unless otherwise indicated, approved sample units may become part of the completed Work if in undisturbed condition at time of Substantial Completion. Notify Architect of their locations.

1.5 CLOSEOUT SUBMITTALS

- A. Quality Standard Compliance Certificates: AWI's Quality Certification Program certificates.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer and Licensed participate in AWI's Quality Certification Program.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect finished surfaces during handling and installation with protective covering of polyethylene film or other suitable material.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Do not deliver or install casework until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during remainder of construction period. Maintain temperature and relative humidity during remainder of construction period in range recommended for Project location by the AWI/AWMAC/WI's "Architectural Woodwork Standards."
- B. Established Dimensions: Where casework is indicated to fit to other construction, establish dimensions for areas where casework is to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.
- C. Field Measurements: Where casework is indicated to fit to existing construction, verify dimensions of existing construction by field measurements before fabrication and indicate measurements on Shop Drawings. Provide fillers and scribes to allow for trimming and fitting.
- D. Locate concealed framing, blocking, and reinforcements that support casework by field measurements before enclosing them, and indicate measurements on Shop Drawings.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of casework that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Delamination of components or other failures of glue bond.
 - b. Warping of components.

- c. Failure of operating hardware.
- 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR CASEWORK

- A. Quality Standard: Unless otherwise indicated, comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards" for grades of casework indicated for construction, finishes, installation, and other requirements.
 - 1. Grade: Premium.
 - 2. Provide labels and certificates from AWI certification program indicating that casework complies with requirements of grades specified.
- B. Product Designations:
 - 1. Drawings indicate sizes, configurations, and finish materials of manufactured plastic-laminate-clad casework by referencing designated manufacturer's catalog numbers. Other manufacturers' casework of similar sizes and door and drawer configurations, of same finish materials, and complying with the Specifications may be considered. See Section 01 6000 "Product Requirements."

2.2 PLASTIC-LAMINATE-CLAD CASEWORK

- A. Source Limitations: Obtain from single source from single manufacturer.
- B. Design: Frameless cabinet construction with the following door and drawer-front style:
 - 1. Flush overlay.
- C. Grain Direction for Wood-Grain Plastic Laminate:
 - 1. Doors: Vertical with continuous vertical matching.
 - 2. Drawer Fronts: Vertical with continuous vertical matching.
 - 3. Face Frame Members: Lengthwise.
 - 4. End Panels: Vertical.
 - 5. Bottoms and Tops of Units: Side to side.
 - 6. Knee Space Panels: Vertical.
 - 7. Aprons: Vertical.
- D. Exposed Materials:
 - 1. Plastic-Laminate Grade: HGS.
 - a. Colors and Patterns: As indicated on Drawings.
 - 2. Edgebanding: PVC.
 - a. PVC Edgebanding Color: As indicated on Drawings.
- E. Semiexposed Materials:
 - 1. Plastic Laminate: Grade VGS unless otherwise indicated. Provide plastic laminate for semiexposed surfaces unless otherwise indicated.
 - a. Colors and Patterns: As indicated by manufacturer's designations.

- b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.
 - 2. Thermally Fused Laminate (TFL) Panels: Provide thermally fused laminate panels for semiexposed surfaces unless otherwise indicated.
 - a. Colors and Patterns: As selected by Architect from manufacturer's full range.
 - b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.
 - 3. Hardboard: Use only for cabinet backs where exterior side of back is not exposed.
 - 4. Unless otherwise indicated, provide specified edgebanding on all semiexposed edges.
- F. Concealed Materials:
 - 1. Solid Wood: With no defects affecting strength or utility.
 - 2. Plywood: Hardwood plywood.
 - 3. Plastic Laminate: Grade VGS.
 - 4. Particleboard.
 - 5. MDF.
 - 6. Hardboard.

2.3 HARDWARE AND ACCESSORIES

- A. Hardware: Unless otherwise indicated, provide manufacturer's standard satin-finish, commercial-quality, heavy-duty hardware.
 - 1. Use threaded metal or plastic inserts with machine screws for fastening to particleboard except where hardware is through-bolted from back side.
- B. Frameless Concealed Hinges (European Type): ANSI/BHMA A156.9, Type B01602, self-closing. Provide two hinges for doors less than 48 inches high, and provide three hinges for doors more than 48 inches high.
 - 1. Degrees of Opening: 165 degrees.
- C. Wire Pulls: Solid stainless steel wire pulls, fastened from back with two screws.
 - 1. For sliding doors, provide recessed stainless steel flush pulls.
 - 2. Provide two pulls for drawers more than 24 inches wide.
- D. Door Catches: nylon-roller spring catch. Provide two catches on doors more than 48 inches high.
- E. Door and Drawer Bumpers: Self-adhering, clear silicone rubber.
 - 1. Doors: Provide one bumper at top and bottom of closing edge of each swinging door.
 - 2. Drawers: Provide one bumper on back side of drawer front at each corner.
- F. Drawer Slides: ANSI/BHMA A156.9.
 - 1. Manufacturer's standard.

2. Heavy Duty (Grade 1HD-100): Side mount.
 - a. Type: Full extension.
 - b. Material: Zinc-plated steel slides.
 - c. Motion Feature: Soft close dampener.
 3. General-purpose drawers; provide 100 lb load capacity.
 4. File drawers; provide 150 lb load capacity.
- G. Drawer and Hinged-Door Locks: Cylindrical (cam) type, five-pin tumbler, brass with chrome-plated finish, and complying with ANSI/BHMA A156.11, Grade 1.
1. Provide a minimum of two keys per lock and six master keys.
 2. Provide locks where indicated.
 - a. Master key for up to 500 key changes.
- H. Sliding-Door Hardware Sets: Manufacturer's standard, to suit type and size of sliding-door unit.

2.4 MATERIALS

- A. Maximum Moisture Content for Lumber: 7 percent for hardwood and 12 percent for softwood.
- B. Hardwood Plywood: HPVA HP-1, particleboard core except where veneer core is indicated.
- C. Softwood Plywood: DOC PS 1.
- D. Particleboard: ANSI A208.1, Grade M-2.
- E. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.
- F. Hardboard: ANSI A135.4, Class 1 tempered.
- G. Plastic Laminate: High-pressure decorative laminate complying with ISO 4586-3.
1. Basis of Design: Subject to compliance with requirements, provide Wilsonart or comparable product by one of the following:
 - a. Arborite, Division of Wilsonart Canada ULC
 - b. Formica Corporation
 - c. Nevamar; a Panolam Industries International, Inc. brand
 2. Source Limitations: Obtain from single source from single manufacturer.
- H. PVC Edgebanding for Plastic Laminate: Rigid PVC extrusions, through color with satin finish, 3.0 mm thick at doors and drawer fronts, 1.0 mm thick elsewhere.
- I. Thermally Fused Laminate Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper and complying with requirements of ISO 4586.
1. Edgebanding for Thermally Fused Laminate (TFL) Panels: PVC or polyester edgebanding matching thermally fused laminate panels.

2.5 FABRICATION

- A. Plastic-Laminate-Clad Cabinet Construction: As required by referenced quality standard, but not less than the following:
1. Bottoms and Ends of Cabinets, and Tops of Wall Cabinets and Tall Cabinets: 3/4-inch particleboard.
 2. Shelves: 3/4-inch- thick particleboard.
 3. Backs of Casework: 1/2-inch- thick particleboard or MDF where exposed, 1/4-inch- thick hardboard dadoed into sides, bottoms, and tops where not exposed.
 4. Drawer Fronts: 3/4-inch MDF.
 5. Drawer Sides and Backs: 1/2-inch- thick MDF, with glued dovetail or multiple-dowel joints.
 6. Drawer Bottoms: 1/4-inch- thick MDF glued and dadoed into front, back, and sides of drawers. Use 1/2-inch material for drawers more than 24 inches wide.
 7. Cabinet Doors:
 - a. 48 Inches (1220 mm) High or Less: 3/4 inch thick, with particleboard or MDF cores.
 - b. 48 Inches (1220 mm) or More in Height: 1-1/8 inches thick, with particleboard cores.
- B. Filler Strips: Provide as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as casework.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances, location of framing and reinforcements, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Grade: Install casework to comply with same quality standard grade as item to be installed.
- B. Install casework level, plumb, and true in line; shim as required using concealed shims. Where casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.
- C. Base Cabinets: Set cabinets straight, level, and plumb. Adjust subtops within 1/16 inch of a single plane. Align similar adjoining doors and drawers to a tolerance of 1/16 inch. Bolt adjacent cabinets together with joints flush, tight, and uniform.

- D. Wall Cabinets: Hang cabinets straight, level, and plumb. Adjust fronts and bottoms within 1/16 inch of a single plane. Fasten cabinets to hanging strips, masonry, framing, wood blocking, or reinforcements in walls and partitions. Align similar adjoining doors to a tolerance of 1/16 inch.
- E. Fasten casework to adjacent units and to masonry, framing, wood blocking, or reinforcements in walls and partitions to comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards."
- F. Install hardware uniformly and precisely. Set hinges snug and flat in mortises unless otherwise indicated. Adjust and align hardware so moving parts operate freely and contact points meet accurately. Allow for final adjustment after installation.
- G. Adjust operating hardware so doors and drawers operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

3.3 FIELD QUALITY CONTROL

- A. Inspections: Provide inspection of installed Work through AWI's Quality Certification Program certifying that woodwork, including installation, complies with requirements of the Architectural Woodwork Standards for the specified grade.
 - 1. Inspection entity to prepare and submit report of inspection.

3.4 CLEANING

- A. Repair or remove and replace defective work as directed on completion of installation.
- B. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

END OF SECTION 12 3216

SECTION 12 3623.13 - PLASTIC-LAMINATE-CLAD COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Plastic-laminate-clad countertops.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include data for fire-retardant treatment from chemical-treatment manufacturer and certification by treating plant that treated materials comply with requirements.
- B. Shop Drawings:
 - 1. Plans, sections, details, edge and backsplash profiles, and attachments to other work.
 - 2. Locations and details of joints.
 - 3. Locations and sizes of cutouts and holes for items installed in countertop.
 - 4. Apply AWI's Quality Certification Program label to Shop Drawings.
- C. Samples for Verification:
 - 1. Plastic Laminates: For each type, color, pattern, and surface finish required, 3 inches by 5 inches in size.
 - 2. Wood-Grain Plastic Laminates: For each type, color, pattern, and surface finish required, 3 inches by 5 inches in size.

1.3 INFORMATIONAL SUBMITTALS

- A. Quality Standard Compliance Certificates: AWI's Quality Certification Program.

1.4 QUALITY ASSURANCE

- A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.
 - 1. Shop Certification: AWI's Quality Certification Program accredited participant.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver countertops only after casework and supports on which they will be installed have been completed in installation areas.
- B. Store countertops in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.
- C. Keep surfaces of countertops covered with protective covering during handling and installation.

1.6 FIELD CONDITIONS

- A. Environmental Limitations without Humidity Control: Do not deliver or install countertops until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during the remainder of the construction period.
- B. Environmental Limitations with Humidity Control: Do not deliver or install countertops until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F and relative humidity between 25 and 55 percent during the remainder of the construction period.
- C. Field Measurements: Where countertops are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
- D. Established Dimensions: Where countertops are indicated to fit to other construction, establish dimensions for areas where countertops are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.1 PLASTIC-LAMINATE-CLAD COUNTERTOPS

- A. Quality Standard: Unless otherwise indicated, comply with NAAWS for grades of plastic-laminate-clad countertops indicated for construction, finishes, installation, and other requirements.
 - 1. Provide inspections of fabrication with labels and certificates from AWI certification program indicating that countertops comply with requirements of grade specified.
- B. Grade: Premium.
- C. High-Pressure Decorative Laminate: ISO 4586-3, Grade HGS.
 - 1. Basis-of-Design: Subject to compliance with requirements, provide Wilsonart or comparable product by one of the following:
 - a. Arborite, Division of Wilsonart Canada ULC
 - b. Formica Corporation
 - c. Nevamar; a Panolam Industries International, Inc. brand
- D. Colors, Patterns, and Finishes: As indicated on Drawings
- E. Edge Treatment: As indicated on Drawings.
- F. Core Material: MDF.
- G. Core Material at Sinks: Particleboard made with exterior glue.

- H. Core Thickness:
 - 1. Build up countertop thickness to 1-1/2 inches at front, back, and ends with additional layers of core material laminated to top.

2.2 WOOD MATERIALS

- A. Wood Products: Provide materials that comply with requirements of referenced quality standard unless otherwise indicated.
 - 1. Composite Wood Products: Verify products are made using ultra-low-emitting formaldehyde resins, as defined in CARB 93120, "Airborne Toxic Control Measure (ATCM) for Formaldehyde Emissions from Composite Wood Products," or are made with no added formaldehyde.
 - 2. Particleboard: ANSI A208.1, MR 10.
 - a. Grade M-2 or better; complying with performance requirements specified.

2.3 MISCELLANEOUS MATERIALS

- A. Adhesives: Do not use adhesives that contain urea formaldehyde.
- B. Adhesive for Bonding Plastic Laminate: Type I, waterproof type as selected by fabricator to comply with requirements.
 - 1. Adhesive for Bonding Edges: Hot-melt adhesive.
- C. Installation Adhesive: Manufacturer's standard product that is recommended for application indicated.
 - 1. Verify adhesives have a VOC content of 70 g/L or less.

2.4 FABRICATION

- A. Sand fire-retardant-treated wood lightly to remove raised grain on exposed surfaces before fabrication.
- B. Fabricate countertops to dimensions, profiles, and details indicated. Provide front and end overhang of 1 inch over base cabinets. Ease edges to radius indicated for the following:
 - 1. Solid-Wood (Lumber) Members: 1/16 inch unless otherwise indicated.
- C. Complete fabrication, including assembly, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates to receive countertops and conditions under which countertops will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of countertops.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Before installation, condition countertops to average prevailing humidity conditions in installation areas.
- B. Examine shop-fabricated work for completion and complete work as required, including removal of packing.

3.3 INSTALLATION OF PLASTIC-LAMINATE-CLAD COUNTERTOPS

- A. Grade: Install countertops to comply with same grade as item to be installed.
- B. Assemble countertops and complete fabrication at Project site to extent that it was not completed in the shop.
 - 1. Provide cutouts for appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately, and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.
 - 2. Seal edges of cutouts by saturating with varnish.
- C. Field Jointing: Where possible, make in the same manner as shop jointing, using dowels, splines, adhesives, and fasteners recommended by manufacturer. Prepare edges to be joined in shop so Project-site processing of top and edge surfaces is not required. Locate field joints where indicated on Shop Drawings.
 - 1. Secure field joints in countertops with concealed clamping devices located within 6 inches of front and back edges and at intervals not exceeding 24 inches. Tighten in accordance with manufacturer's written instructions to exert a constant, heavy-clamping pressure at joints.
- D. Countertop Installation:
 - 1. Scribe and cut countertops to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
 - 2. Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.
 - 3. Anchor wall cleating necessary for proper setting for countertops not supported by casework.
 - 4. Install countertops level and true in line. Use concealed shims as required to maintain not more than 1/8-inch-in-96-inch variation from a straight, level plane.
 - 5. Secure backsplashes to walls with adhesive.
 - 6. Seal joints between countertop and backsplash, if any, and joints where countertop and backsplash abut walls with mildew-resistant silicone sealant or another permanently elastic sealing compound recommended by countertop material manufacturer.

3.4 ADJUSTING AND CLEANING

- A. Repair damaged and defective countertops, where possible, to eliminate functional and visual defects. Where impossible to repair, replace countertops. Adjust joinery for uniform appearance.
- B. Clean countertops on exposed and semiexposed surfaces.
- C. Protection: Provide kraft paper or other suitable covering over countertop surfaces, taped to underside of countertop at a minimum of 48 inches o.c. Remove protection at Substantial Completion.

END OF SECTION 12 3623.13

SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section includes:
 - 1. Motors.
 - 2. Sleeves without waterstop.
 - 3. Sleeves with waterstop.
 - 4. Stack-sleeve fittings.
 - 5. Sleeve-seal systems.
 - 6. Grout.
 - 7. Silicone sealants.
 - 8. Escutcheons.

1.2 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product, excluding motors which are included in Part 1 of the fire-suppression equipment Sections.
 - a. Include construction details, material descriptions, and dimensions of components.
 - b. Include operating characteristics and furnished accessories.
- B. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 MOTORS**

- A. Motor Requirements, General:
1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
 2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
 3. Comply with NEMA MG 1 unless otherwise indicated.
- B. Motor Characteristics:
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 ft. above sea level.
 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- C. Polyphase Motors:
1. Description: NEMA MG 1, Design B, medium induction motor.
 2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
 3. Service Factor: 1.15.
 4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
 5. Multispeed Motors, Multiple Winding: Separate winding for each speed.
 6. Rotor: Random-wound, squirrel cage.
 7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
 8. Temperature Rise: Match insulation rating.
 9. Insulation: Class F.
 10. Code Letter Designation:
 - a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
 11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- D. Additional Requirements for Polyphase Motors:
1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
 2. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.

- b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- E. Single-Phase Motors:
 - 1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
 - 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
 - 3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
 - 4. Motors 1/20 HP and Smaller: Shaded-pole type.
 - 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.
- F. Electronically Commutated Motors:
 - 1. Microprocessor-Based Electronic Control Module: Converts 120 V or 240 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
 - 2. Three-phase power motor module with permanent magnet rotor.
 - 3. Circuit board or digital speed controller/LED display.
 - 4. Building Automation System Interface: Via DC voltage signal.

2.2 SLEEVES AND SLEEVE SEALS

- A. Sleeves without Waterstop:
 - 1. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
 - 2. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
 - 3. Steel Sheet Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
 - 4. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
- B. Sleeves with Waterstop:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC
 - b. CALPICO, Inc.
 - c. GPT; a division of EnPRO Industries
 - d. Metraflex Company (The)
 - 2. Description: Manufactured steel stainless steel galvanized steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

- C. Stack-Sleeve Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Wade; a subsidiary of McWane Inc.
 - c. Zurn Industries, LLC
 2. Description: Manufactured, Dura-coated or Duco-coated or galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with setscrews.
- D. Sleeve-Seal Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC
 - b. CALPICO, Inc.
 - c. GPT; a division of EnPRO Industries
 - d. Metraflex Company (The)
 - e. Proco Products, Inc
 2. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - a. Hydrostatic Seal: 20 psig minimum.
 - b. Sealing Elements: EPDM-rubber, High-temperature-silicone and Nitrile (Buna-N) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 - c. Pressure Plates: Carbon steel, Stainless steel or Stainless steel, Type 316.
 - d. Connecting Bolts and Nuts: Stainless steel or Stainless steel, Type 316, of length required to secure pressure plates to sealing elements.
- E. Grout:
1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
 2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 3. Design Mix: 5000 psi, 28-day compressive strength.
 4. Packaging: Premixed and factory packaged.
- F. Silicone Sealants:
1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) GE Construction Sealants; Momentive Performance Materials Inc.
 - 2) ITW Polymers Sealants North America
 - 3) Polymeric Systems, Inc.; PPG Industries, Inc.
 - 4) Sherwin-Williams Company (The)
 - 5) Sika Corporation

- 6) The Dow Chemical Company
 - 7) Tremco Incorporated
 - b. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.
2. Silicone Sealant, S, P, T, NT: Single-component, 100/50, pourable, plus 100 percent and minus 50 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Pecora Corporation
 - 2) Sika Corporation
 - 3) The Dow Chemical Company
 - 4) Tremco Incorporated
 - b. Standard: ASTM C920, Type S, Grade P, Class 100/50, Uses T and NT.
3. Silicone Foam Sealant: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Smooth-On
4. Sealant shall have a VOC content of 250 g/L or less.
 - a. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - b. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - c. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - d. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - e. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.3 ESCUTCHEONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. BrassCraft Manufacturing Co.; a Masco company
 2. Dearborn Brass

3. Jones Stephens Corp.
 4. Keeney Manufacturing Company (The)
 5. Mid-America Fittings, LLC; A Midland Industries Company
 6. ProFlo; a Ferguson Enterprises, Inc. brand
- B. Escutcheon Types:
1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- C. Floor Plates:
1. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Install pipe loops and offsets in accordance with NFPA 13 requirements for expansion and contraction compensation.

3.2 INSTALLATION OF SLEEVES, GENERAL

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 2-inch annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout or silicone sealant, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire-resistance of floor/slab/wall.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.

- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 8413 "Penetration Firestopping."

3.3 INSTALLATION OF SLEEVES WITH WATERSTOP

- A. Install sleeve with waterstop as new walls and slabs are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange centered across width centered in concrete slab or wall.
- C. Secure nailing flanges to wooden concrete forms.
- D. Using grout or silicone sealant, seal space around outside of sleeves.

3.4 INSTALLATION OF STACK-SLEEVE FITTINGS

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing.
 - 3. Install section of cast-iron soil pipe to extend sleeve to 3 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- or smoke-stop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

3.5 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.6 INSTALLATION OF ESCUTCHEONS

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

3.7 FIELD QUALITY CONTROL

- A. Sleeves and Sleeve Seals:
 - 1. Perform the following tests and inspections:
 - a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
 - b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
 - 2. Prepare test and inspection reports.
- B. Escutcheons:
 - 1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.8 SLEEVES APPLICATION

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above and below Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 2. Concrete Slabs-on-Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs above Grade:
 - a. Sleeves with waterstops.
 - 4. Interior Walls and Partitions:
 - a. Sleeves without waterstops.

3.9 ESCUTCHEONS APPLICATION

- A. Escutcheons for New Piping and Relocated Existing Piping:
 - 1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 - 2. Chrome-Plated Piping: One piece, cast brass with polished, chrome-plated finish.
 - 3. Insulated Piping:
 - a. One piece, cast brass with polished, chrome-plated finish.
 - 4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a. One piece, cast brass with polished, chrome-plated finish.
 - 5. Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a. One piece, cast brass with polished, chrome-plated finish.
 - 6. Bare Piping in Equipment Rooms:
 - a. One piece, steel with polished, chrome-plated finish.
 - b. One piece, cast brass with polished, chrome-plated finish.
- B. Install floor plates for piping penetrations of equipment room floors.
- C. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and

with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: One piece, floor plate.
2. Existing Piping: Split floor plate.

END OF SECTION 21 0500

SECTION 21 0523 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Two-piece ball valves with indicators.
 - 2. Bronze butterfly valves with indicators.
 - 3. Check valves.
 - 4. Bronze OS&Y gate valves.
 - 5. NRS gate valves.
 - 6. Trim and drain valves.

1.2 DEFINITIONS

- A. NRS: Nonrising stem.
- B. OS&Y: Outside screw and yoke.
- C. SBR: Styrene-butadiene rubber.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and weld ends.
 - 3. Set valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.
- D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS**2.1 SOURCE LIMITATIONS**

- A. Obtain each type of valve from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
1. Fire Main Equipment: HAMV - Main Level.
 - a. Indicator Posts, Gate Valve: HCBZ - Level 1.
 - b. Ball Valves, System Control: HLUG - Level 3.
 - c. Butterfly Valves: HLXS - Level 3.
 - d. Check Valves: HMER - Level 3.
 - e. Gate Valves: HMRZ - Level 3.
 2. Sprinkler System and Water Spray System Devices: VDGT - Main Level.
 - a. Valves, Trim and Drain: VQGU - Level 1.
- B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves.
 - 3) Miscellaneous valves.
- C. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B31.9 for building services piping valves.
- D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- E. NFPA Compliance for Valves:
1. Comply with NFPA 13, NFPA 14, NFPA 20, and NFPA 24.
- F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher, as required by system pressures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Actuator Types:
1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 2. Handwheel: For other than quarter-turn trim and drain valves.
 3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.3 TWO-PIECE BALL VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ames Fire & Waterworks; A Watts Water Technologies Company
 2. NIBCO INC.
 3. Victaulic Company
- B. Description:
1. UL 1091, except with ball instead of disc and FM Global approved for indicating valves (butterfly or ball type), Class Number 1112.
 2. Minimum Pressure Rating: 175 psig.
 3. Body Design: Two piece.
 4. Body Material: Forged brass or bronze.
 5. Port Size: Full or standard.
 6. Seats: PTFE.
 7. Stem: Bronze or stainless steel.
 8. Ball: Chrome-plated brass.
 9. Actuator: Worm gear
 10. Supervisory Switch: Internal or external.
 11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
 12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.4 BRONZE BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ALEUM USA
 2. Globe Fire Sprinkler Corporation
 3. Milwaukee Valve Company
- B. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
 2. Minimum: Pressure rating: 175 psig.
 3. Body Material: Bronze.
 4. Seat Material: EPDM.
 5. Stem Material: Bronze or stainless steel.
 6. Disc: Bronze or Stainless steel.
 7. Actuator: Worm gear.
 8. Supervisory Switch: Internal or external.
 9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
 10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.5 CHECK VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ALEUM USA
 2. Ames Fire & Waterworks; A Watts Water Technologies Company

3. Anvil; an ASC Engineered Solution
4. FEBCO; A WATTS Brand
5. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International
6. Globe Fire Sprinkler Corporation
7. Kennedy Valve Company; a division of McWane, Inc.
8. Matco-Norca
9. Mueller Co. LLC; Mueller Water Products, Inc.
10. NIBCO INC.
11. Reliable Automatic Sprinkler Co., Inc. (The)
12. Shurjoint; a part of Aalberts Integrated Piping Systems
13. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
14. United Brass Works, Inc
15. Venus Fire Protection Ltd.
16. Victaulic Company
17. Viking Group Inc.
18. WATTS; A Watts Water Technologies Company
19. Wilson & Cousins Inc.
20. Zurn Industries, LLC

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.6 BRONZE OS&Y GATE VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Milwaukee Valve Company
2. NIBCO INC.
3. United Brass Works, Inc
4. Zurn Industries, LLC

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.

7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.7 NRS GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Cast Iron Pipe Company
 2. Clow Valve Company; a subsidiary of McWane, Inc.
 3. Mueller Co. LLC; Mueller Water Products, Inc.
 4. NIBCO INC.
 5. Victaulic Company
 6. Zurn Industries, LLC
- B. Description:
1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
 2. Minimum Pressure Rating: 175 psig.
 3. Body and Bonnet Material: Cast or ductile iron.
 4. Wedge: Cast or ductile iron with elastomeric coating.
 5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
 6. Stem: Brass or bronze.
 7. Packing: Non-asbestos PTFE.
 8. Supervisory Switch: External.
 9. End Connections: Grooved.

2.8 TRIM AND DRAIN VALVES

- A. Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Croker; a Division of Morris Group International
 - c. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International
 - d. Flowserve Corporation
 - e. Jomar Valve
 - f. KITZ Corporation
 - g. Metso Automation USA Inc.
 - h. Milwaukee Valve Company
 - i. NIBCO INC.
 - j. Potter Roemer LLC; a Division of Morris Group International
 - k. Red-White Valve Corp.
 - l. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 - m. Victaulic Company
 - n. WATTS; A Watts Water Technologies Company
 - o. Zurn Industries, LLC

2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Design: Two piece.
 - c. Body Material: Forged brass or bronze.
 - d. Port size: Full or standard.
 - e. Seats: PTFE.
 - f. Stem: Bronze or stainless steel.
 - g. Ball: Chrome-plated brass.
 - h. Actuator: Handlever.
 - i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
 - j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.
- B. Angle Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire Protection Products Inc (FPPI); a brand of Anvil International and Smith-Cooper International
 - b. NIBCO INC.
 - c. United Brass Works, Inc
 2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Material: Brass or bronze.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 INSTALLATION, GENERAL

- A. Comply with requirements in the following Sections for specific valve-installation requirements and applications:
 - 1. Section 21 1000 "Water-Based Fire-Suppression Systems" for application of valves in fire-suppression standpipes; wet-pipe, fire-suppression sprinkler systems; and dry-pipe, fire-suppression sprinkler systems.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply, except from fire-department connections. Install permanent identification signs, indicating portion of system controlled by each valve.
- C. Install double-check valve assembly in each fire-protection water-supply connection.
- D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the pipe center.
- F. Install valves in position to allow full stem movement.
- G. Install valve tags. Comply with requirements in Section 21 0553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 21 0523

SECTION 21 0529 - HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe hangers and supports for fire-suppression piping - metal.
 - 2. Equipment supports.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING - METAL

- A. Pipe Hangers and Supports for Fire-Suppression Piping - Carbon Steel:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. FNW; Ferguson Enterprises, Inc.
 - 2. Description: Factory-fabricated components, NFPA approved, UL listed, or FM Global approved for fire-suppression piping support.
 - 3. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
 - 4. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.2 EQUIPMENT SUPPORTS

- A. Description: NFPA-approved, UL-listed, or FM Global-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.3 MATERIALS

- A. Carbon Steel: ASTM A1011/A1011M.
- B. Stainless Steel: ASTM A240/A240M.
- C. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000 psi, 28-day compressive strength.

PART 3 - EXECUTION**3.1 APPLICATION**

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry static loads within specified loading limits. Minimum static design load used for strength determination is to comply with NFPA 13 requirements, minimum 5 times the water-filled weight of piping and supported components plus 250 lb.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, permit freedom of movement between pipe anchors, and facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- B. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- C. Pipe Slopes: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- D. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

3.3 INSTALLATION OF EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- E. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
- F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- G. Hanger-Rod Attachments: Comply with NFPA requirements.
- H. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. C-Clamps (MSS Type 23): For structural shapes.
 - 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

END OF SECTION 21 0529

SECTION 21 0553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Valve tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Champion America
 - d. Craftmark Pipe Markers
 - e. emedco
 - f. Kolbi Pipe Marker Co.
 - g. LEM Products Inc.
 - h. Marking Services Inc.
 - i. Pipemarket.com; Brimar Industries, Inc.
 - j. Seton Identification Products; a Brady Corporation company
 - 2. Material and Thickness: aluminum, 0.032 inch thick, with predrilled or stamped holes for attachment hardware.
 - 3. Letter and Background Color: As indicated for specific application under Part 3.
 - 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 6. Fasteners: Stainless steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation

- b. Carlton Industries, LP
 - c. Champion America
 - d. Craftmark Pipe Markers
 - e. emedco
 - f. Kolbi Pipe Marker Co.
 - g. LEM Products Inc.
 - h. Marking Services Inc.
 - i. Pipemarker.com; Brimar Industries, Inc.
 - j. Seton Identification Products; a Brady Corporation company
- 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
 - 3. Letter and Background Color: As indicated for specific application under Part 3.
 - 4. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 7. Fasteners: Stainless steel rivets or self-tapping screws.
 - 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation
 - 3. Carlton Industries, LP
 - 4. Champion America
 - 5. Craftmark Pipe Markers
 - 6. emedco
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Pipemarker.com; Brimar Industries, Inc.
 - 11. Seton Identification Products; a Brady Corporation company
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include the following:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.3 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation
 - 3. Carlton Industries, LP
 - 4. Champion America
 - 5. Craftmark Pipe Markers
 - 6. emedco
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Pipemarker.com; Brimar Industries, Inc.
 - 11. Seton Identification Products; a Brady Corporation company
- B. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: aluminum, 0.031 inch thick, with predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass beaded chain.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Include valve-tag schedule in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

- A. Permanently fasten labels on each item of fire-suppression equipment.
- B. Sign and Label Colors:
 - 1. White letters on an ANSI Z535.1 safety-red background.
- C. Locate equipment labels where accessible and visible.
- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF PIPE LABELS

- A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit a view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.
- C. Flow- Direction Arrows: Provide arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- D. Fire-Suppression Pipe Label Color Schedule:
 - 1. Fire-Suppression Pipe Labels: White letters on an ANSI Z535.1 safety-red background.

3.5 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule in the operating and maintenance manual. Include the identification "FSV" on all fire-suppression system valve tags.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.
 - 1. Valve-Tag Size and Shape:
 - a. Wet-Pipe Sprinkler System: 2 inches, round.
 - 2. Valve-Tag Color: White letters on an ANSI Z535.1 safety-red background.

END OF SECTION 21 0553

SECTION 21 1000 - WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fire-suppression piping, fittings, and appurtenances.
 - 2. Fire-suppression piping specialties.
 - 3. Sprinklers.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
- C. Shop Drawings:
 - 1. Prepare in accordance with NFPA 13 section "Working Plans."
 - a. Include plans, elevations, and sections of the system piping and details.
 - b. Include detailed riser diagram and schematic diagram showing system supply, supply connection, devices, valves, pipe and fittings, as well as the delineation of the standard-pressure and high-pressure portions of the fire-suppression system.
 - c. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Prepare computer-generated hydraulic calculations in accordance with the following:
 - a. Minimum operating pressure at hydraulically most remote fire hose valve is to be 100 psig.
 - b. Name of hydraulic program used.
 - c. Water supply information, including fire hydrant flow test data report.
 - 3. Submit documents and calculations signed and sealed by qualified professional engineer responsible for their preparation and prepared by NICET Level III-certified technician, "Water-Based Systems Layout." NICET certified-technician submittals are to include the following information on each drawing title block: technician's name, NICET certification number, and NICET certification specialty area and level.
 - 4. Include diagrams for power, signal, and control wiring.

- D. Delegated Design Submittals: For fire-suppression systems indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation. prepared by NICET Level III-certified technician, "Water-Based Systems Layout." NICET certified-technician submittals are to include the following information on each drawing title block: technician's name, NICET certification number, and NICET certification specialty area and level.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Fire-suppression system plans and sections, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Design Data: Approved fire-suppression piping working plans, prepared in accordance with NFPA 13, including documented approval by AHJs, and including hydraulic calculations if applicable.
- C. Welding certificates.
- D. Field Test Reports:
1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
 2. Fire-hydrant flow test report.
- E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-suppression systems and specialties to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.
 2. System control valves.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

1.7 FIELD CONDITIONS

- A. Interruption of Existing Fire-Suppression Service: Do not interrupt fire-suppression service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire-suppression service in accordance with requirements indicated:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-suppression service.
 - 2. Do not proceed with interruption of fire-suppression service without Owner's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Automatic wet-pipe sprinkler system.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Suppression System Components, Devices, and Accessories: Listed in ULSE's "Fire Protection Equipment Directory" and FM Approvals' "Approval Guide."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fire-suppression system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.
- D. Standard-Pressure Piping System Component: Listed for 175 psig minimum working pressure.
- E. Delegated Design: Engage a qualified professional engineer to design fire-suppression systems.
 - 1. Perform fire-hydrant flow test and record the following conditions:
 - a. Date: Insert test date.

- b. Time: Insert time a.m. p.m.
 - c. Performed by: Insert operator's name of Insert firm.
 - d. Location of Residual Fire Hydrant R: Insert location.
 - e. Location of Flow Fire Hydrant F: Insert location.
 - f. Static Pressure at Residual Fire Hydrant R: Insert psig.
 - g. Measured Flow at Flow Fire Hydrant F: Insert gpm.
 - h. Residual Pressure at Residual Fire Hydrant R: Insert psig.
- 2. Fire-hydrant flow test must be performed within previous 12 months prior to completion of design documents and hydraulic calculations.
 - 3. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
 - 4. Sprinkler Occupancy Hazard Classifications:
 - a. Educational: Light Hazard.
 - 5. Minimum Density for Automatic-Sprinkler Piping Design:
 - 6. Light-Hazard Occupancy: 0.10 gpm/sq. ft. over 1500 sq. ft. area.
 - 7. Maximum protection area per sprinkler in accordance with ULSE listing.
 - 8. Total Combined Hose-Stream Demand Requirement: In accordance with NFPA 13 unless otherwise indicated:
 - 9. Light-Hazard Occupancies: 100 gpm for 30 minutes.
- F. Obtain documented approval of fire-suppression system design from AHJs.

2.3 FIRE-SUPPRESSION PIPING, FITTINGS, AND APPURTENANCES

- A. Steel Pipe, Fittings, and Appurtenances:
- 1. Schedule 40 Steel Pipe: Galvanized- and black-steel pipe, ASTM A53/A53M, ASTM A135/A135M, or ASTM A795/A795M.
 - a. Standards:
 - 1) UL 852.
 - 2) FM 1630.
 - b. Factory-applied exterior coating.
 - c. Factory-applied bacterial-resistant internal coating to reduce microbiologically influenced corrosion.
 - d. Pipe ends may be factory or field formed to match joining method.
 - 2. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
 - a. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
 - 3. Plain-End-Pipe Fittings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gruvlok; an ASC Engineered Solution
 - 2) Shurjoint; a part of Aalberts Integrated Piping Systems
 - 3) Victaulic Company
 - b. Pressure Rating: 175 psig minimum.
 - c. Plain-End Fittings for Steel Piping: Galvanized or painted plain-end fittings, ASTM A53/A53M, carbon steel or ASTM A106/A106M, forged steel with dimensions matching steel pipe.

- d. Plain-End-Pipe Couplings for Steel Piping: Rigid pattern for steel-pipe dimensions, ductile-iron or malleable-iron housing. Include EPDM-rubber gasket, and bolts and nuts.
- 4. Grooved-Joint, Steel-Pipe Appurtenances:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) CPS Products, Inc.
 - 2) Gruvlok; an ASC Engineered Solution
 - 3) Shurjoint; a part of Aalberts Integrated Piping Systems
 - 4) Smith-Cooper International
 - 5) SPF/Anvil; an ASC Engineered Solution
 - 6) Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 - 7) Victaulic Company
 - b. Pressure Rating: 175 psig minimum.
 - c. Grooved-End Fittings for Steel Piping: Galvanized or Painted grooved-end fittings, ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
 - d. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
- 5. Carbon Steel Pressure-Seal Fittings: UL 213, FM Approvals-approved, 175 psig pressure rating with carbon steel-, zinc-nickel-coated housing, EPDM O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Mueller Streamline Co; a company of Mueller Industries
 - 2) Viega LLC

2.4 FIRE-SUPPRESSION PIPING SPECIALTIES

- A. Branch Outlet Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Shurjoint; a part of Aalberts Integrated Piping Systems
 - b. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 - c. Victaulic Company
 - 2. Standard: UL 213.
 - 3. Pressure Rating: 175 psig minimum.
 - 4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 - 5. Type: Mechanical-tee and -cross fittings.
 - 6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
 - 7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 - 8. Branch Outlets: Grooved, plain-end pipe, or threaded.

- B. Flow Detection and Test Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The)
 - c. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 - d. Victaulic Company
 2. Standard: ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."
 3. Pressure Rating: 175 psig minimum.
 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded or grooved.
- C. Branch Line Testers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Croker; a Division of Morris Group International
 - c. Potter Roemer LLC; a Division of Morris Group International
 2. Standard: UL 199.
 3. Pressure Rating: 175 psig.
 4. Body Material: Brass.
 5. Size: Same as connected piping.
 6. Inlet: Threaded.
 7. Drain Outlet: Threaded and capped.
 8. Branch Outlet: Threaded, for sprinkler.
- D. Sprinkler Inspector's Test Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The)
 - c. Viking Group Inc.
 2. Standard: ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."
 3. Pressure Rating: 175 psig minimum.
 4. Body Material: Cast- or ductile-iron housing with sight glass.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.
- E. Adjustable Drop Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aegis Technologies, Inc.
 2. Standard: UL 1474.
 3. Pressure Rating: 250 psig minimum.

4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
 5. Size: Same as connected piping.
 6. Length: Adjustable.
 7. Inlet and Outlet: Threaded.
- F. Flexible Sprinkler Hose Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ALEUM USA
 - b. Easyflex, Inc.
 - c. Flexhead; an ASC Engineered Solution
 - d. Gateway Tubing, Inc.
 - e. Reliable Automatic Sprinkler Co., Inc. (The)
 - f. Victaulic Company
 2. Standards:
 - a. UL 2443.
 - b. FM 1637.
 3. Description: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
 4. Pressure Rating: 175 psig minimum.
 5. Size: Same as connected piping, for sprinkler.
- G. Pressure-Reducing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CLA-VAL
 - b. Croker; a Division of Morris Group International
 - c. Elkhart Brass Mfg. Co., Inc
 - d. Guardian Fire Equipment, Inc
 - e. OCV Control Valves
 - f. Potter Roemer LLC; a Division of Morris Group International
 - g. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 - h. Victaulic Company
 - i. Wilson & Cousins Inc.
 - j. Zurn Industries, LLC
 2. UL 668 hose valve, with integral UL 1468 reducing device.
 3. Pressure Rating: 300-psig minimum.
 4. Material: Brass or bronze.
 5. Inlet: Female pipe threads.
 6. Outlet: Threaded with or without adapter having male hose threads.
 7. Pattern: Angle or gate.
 8. Finish: Polished chrome plated.
- H. Automatic (Ball-Drip) Drain Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The)
 - b. Viking Group Inc.
 2. Pressure Rating: 175 psig minimum.

3. Type: Automatic draining, ball check.
 4. Size: NPS 3/4.
 5. End Connections: Threaded.
- I. Manual Air Vent/Valve:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 2. Description: Ball valve that requires human intervention to vent air.
 3. Body: Forged brass.
 4. Ends: Threaded.
 5. Minimize Size: 1/2 inch.
 6. Minimum Water Working Pressure Rating: 300 psig.
- J. Automatic Air Vent:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. CLA-VAL
 - c. Engineered Corrosion Solutions
 - d. Metraflex Company (The)
 - e. Reliable Automatic Sprinkler Co., Inc. (The)
 2. Description: Automatic air vent that automatically vents trapped air without human intervention. Approved for use in wet-pipe fire-suppression system.
 3. Vents oxygen continuously from system.
 4. Float valve to prevent water discharge.
 5. Minimum Water Working Pressure Rating: 175 psig.
- K. Automatic Air Vent Assembly:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Engineered Corrosion Solutions
 - c. South-Tek Systems, LLC
 2. Description: Automatic dualair vent assembly that automatically vents trapped air without human intervention, including Y-strainer and ball valve in a pre-piped assembly. Approved for use in wet-pipe fire-suppression system.
 3. Vents oxygen continuously from system.
 4. Float valve to prevent water discharge.
 5. Minimum Water Working Pressure Rating: 175 psig.

2.5 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Reliable Automatic Sprinkler Co., Inc. (The)
 2. Tyco Fire Products; brand of Johnson Controls International plc, Building Solutions North America
 3. Victaulic Company
 4. Viking Group Inc.

- B. Standards:
 - 1. UL 199.
 - 2. UL 1626.
 - 3. UL 1767.
 - 4. FM 2000.
 - 5. FM 2008.
 - 6. FM 2030.
- C. Listed in ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."
- D. Pressure Rating for Sprinklers:
 - 1. Standard Automatic Sprinklers: 175 psig minimum.
- E. Sprinklers, Automatic Wet with Heat-Responsive Element:
 - 1. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
 - 2. Standard Spray, Standard Response:
 - a. Flat, concealed pendent.
 - 3. Standard Spray, Quick Response:
 - a. Flat, concealed pendent.
 - 4. Extended Coverage:
 - a. Flat, concealed pendent.
- F. Sprinkler Finishes: painted.
- G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test. Use results for system design calculations required in "Quality Assurance" Article.
 - 1. Flow test is to be performed to meet the criteria established by NFPA 13.
 - 2. Flow test is to be conducted in accordance with NFPA 291.
 - 3. Test is to be performed during a period of ordinary demand for the water system.
 - 4. To obtain satisfactory test results of expected flow or rated capacities, sufficient discharge should be achieved to cause drop of at least 10 percent.
 - 5. Pitot readings are to be taken at the 2-1/2-inch orifice connection.
 - 6. The pitot reading is to range from 10 to 35 psig.
 - 7. Open additional hydrant outlets as needed to control pitot readings.
 - 8. The pitot pressure and corresponding residual pressure readings are to be taken consecutively as pressure fluctuates between a high number and low number.

- B. Flow Test Data Written Report:
 - 1. Flow data report is to be written in accordance with NFPA 291.
 - 2. Flow data report is to include a copy of all flow data recorded during the test, including a site plan showing the tested fire hydrants with respect to the fire water service to the building. Site plan is to indicate which hydrant was flowed and which hydrant was used for pressure reading. Provide date of test, name of testing agency, and name of individual performing test.
- C. Water Supply Curve: Provide water supply curve based on the lowest supply for a given set of test data. For a given residual pressure reading, the supply is to be graphed utilizing the corresponding pitot pressure/flow reading and static pressure reading.
- D. Documentation is to include calibration certifications for gauges used in the flow tests. The certifications are to be from within the previous six (6) months from a reputable agency recognized for certifying pressure gauges.
- E. Report flow test results promptly and in writing. A copy of the flow test data report is to be submitted with the hydraulic calculations.

3.2 INSTALLATION OF DOMESTIC WATER-SUPPLY CONNECTIONS

- A. Connect fire-suppression water piping to building's interior domestic water-distribution piping. Comply with requirements for interior piping in Section 22 1116 "Domestic Water Piping."

3.3 INSTALLATION OF FIRE-SUPPRESSION PIPING

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
 - 1. Deviations from approved working plans for piping require written approval from AHJs. File written approval with Architect before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of fire-suppression piping.
- C. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

- F. Install inspector's test connections in sprinkler system piping, complete with shutoff valve, and sized and located in accordance with NFPA 13.
- G. Install fire-suppression system piping with drains for complete system drainage. Extend drain piping to exterior of building where possible.
- H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- I. Install automatic (ball drip) drain valve at each check valve for fire department connection, to drain piping between fire department connection and check valve. Install drain piping to and spill over floor drain or to exterior of building.
- J. Install hangers and supports for fire-suppression piping in accordance with NFPA standards. Comply with requirements for hanger materials in NFPA standards.
- K. Fill wet-type fire-suppression system piping with water.
- L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 21 0500 "Common Work Results for Fire-Suppression Piping."
- M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 21 0500 "Common Work Results for Fire-Suppression Piping."
- N. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 21 0500 "Common Work Results for Fire-Suppression Piping."

3.4 INSTALLATION OF PIPING JOINTS

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts in accordance with ASME B31.9.

- G. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Steel-Piping, Pressure-Sealed Joints: Join steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- I. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
 - 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe in accordance with AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings in accordance with AWWA C606 for steel-pipe grooved joints.

3.5 INSTALLATION OF VALVES AND SPECIALTIES

- A. Install listed fire-suppression system control valves, trim and drain valves, specialty valves and trim, controls, and specialties in accordance with manufacturer's installation instructions, NFPA standards, and AHJ.
- B. Install listed fire-suppression system shutoff valves in supervised open position, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Air Vent:
 - 1. Provide at least one air vent at high point in each wet-pipe fire-suppression system in accordance with NFPA standards. Connect vent into top of fire-suppression piping.
 - 2. Provide dielectric union for dissimilar metals, ball valve, and strainer upstream of automatic air vent.
 - 3. Pipe from outlet of air vent to drain.

3.6 INSTALLATION OF SPRINKLERS

- A. Install sprinklers in suspended ceilings symmetrically in center of narrow dimension of acoustical ceiling panels within tolerance of 1/2 inch. Coordinate entire pattern of sprinkler locations with approved reflected ceiling plan.
- B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping in accordance with requirements for identification specified in Section 21 0553 "Identification for Fire-Suppression Piping and Equipment."
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect fire-suppression systems in accordance with NFPA standards.
 - 4. Verify that sprinklers' original factory finish has not been contaminated with dirt, debris, or paint. Sprinklers containing other-than-original factory finish are to be considered defective and replaced with new products. Repair and/or cleaning is not acceptable.
- B. Fire-suppression piping system will be considered defective if it does not pass tests and inspections.
- C. Fire-suppression piping system components considered defective during testing will be replaced with new components. Repair of defective components is not acceptable.
- D. Prepare test and inspection reports.

3.9 CLEANING

- A. Clean dirt and debris from fire-suppression system piping, system control valves, sprinklers, and associated components.
- B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.10 PIPING SCHEDULE

- A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

- B. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2 (DN 50) and Smaller, to Be One of the Following:
 - 1. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 2. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 4. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- C. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), to Be One of the Following:
 - 1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 3. Schedule 40, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 4. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 5. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.

3.11 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Flat concealed sprinklers.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces and locations not generally exposed to view; and wax coated where exposed to acids, chemicals, or other corrosive fumes.
 - 2. Flat Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

END OF SECTION 21 1000

SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Motors.
 - 2. Sleeves without waterstop.
 - 3. Sleeves with waterstop.
 - 4. Stack-sleeve fittings.
 - 5. Sleeve-seal systems.
 - 6. Grout.
 - 7. Silicone sealants.
 - 8. Escutcheons.
 - 9. Thermometers, bimetallic actuated, lead free.
 - 10. Thermowells, lead free.
 - 11. Pressure gauges, dial type, lead free.
 - 12. Gauge attachments, lead free.
 - 13. Test plugs, lead free.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product, excluding motors which are included in Part 1 of the plumbing equipment Sections.
 - a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
 - b. Include operating characteristics and furnished accessories.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product provided

1.4 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 MOTORS**

- A. Motor Requirements, General:
 - 1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
 - 2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
 - 3. Comply with NEMA MG 1 unless otherwise indicated.
 - 4. Comply with IEEE 841 for severe-duty motors.
- B. Motor Characteristics:
 - 1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 ft. above sea level.
 - 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- C. Polyphase Motors:
 - 1. Description: NEMA MG 1, Design B, medium induction motor.
 - 2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
 - 3. Service Factor: 1.15.
 - 4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
 - 5. Multispeed Motors, Two Winding: Separate winding for each speed.
 - 6. Rotor: Random-wound, squirrel cage.
 - 7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
 - 8. Temperature Rise: Match insulation rating.
 - 9. Insulation: Class F.
 - 10. Code Letter Designation:
 - a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
 - 11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- D. Additional Requirements for Polyphase Motors:
 - 1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

2. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.
 - b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.
- E. Single-Phase Motors:
1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
 3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
 4. Motors 1/20 HP and Smaller: Shaded-pole type.
 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.
- F. Electronically Commutated Motors:
1. Microprocessor-Based Electronic Control Module: Converts 120 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
 2. Three-phase power motor module with permanent magnet rotor.
 3. Circuit board or digital speed controller/LED display.

2.2 SLEEVES AND SLEEVE SEALS

- A. Sleeves without Waterstop:
1. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
 2. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
- B. Sleeves with Waterstop:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC
 - b. CALPICO, Inc.
 - c. GPT; a division of EnPRO Industries
 - d. Metraflex Company (The)
 2. Description: Manufactured stainless steel or galvanized-steel, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

C. Stack-Sleeve Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Wade; a subsidiary of McWane Inc.
 - c. Zurn Industries, LLC
2. Description: Manufactured, Dura-coated or Duco-coated galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - a. Underdeck Clamp: Clamping ring with setscrews.

D. Sleeve-Seal Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC
 - b. GPT; a division of EnPRO Industries
 - c. Metraflex Company (The)
 - d. Proco Products, Inc
2. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - a. Hydrostatic Seal: 20 psig minimum.
 - b. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - c. Pressure Plates: Stainless steel.
 - d. Connecting Bolts and Nuts: Stainless steel, Type 316 of length required to secure pressure plates to sealing elements.

E. Grout:

1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
3. Design Mix: 5000 psi, 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Silicone Sealants:

1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) GE Construction Sealants; Momentive Performance Materials Inc.
 - 2) ITW Polymers Sealants North America
 - 3) Polymeric Systems, Inc.; PPG Industries, Inc.
 - 4) Sherwin-Williams Company (The)
 - 5) Sika Corporation
 - 6) The Dow Chemical Company
 - 7) Tremco Incorporated
 - b. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.

2.3 ESCUTCHEONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. BrassCraft Manufacturing Co.; a Masco company
 - 2. Dearborn Brass
 - 3. Jones Stephens Corp.
 - 4. Keeney Manufacturing Company (The)
 - 5. Mid-America Fittings, LLC; A Midland Industries Company
 - 6. ProFlo; a Ferguson Enterprises, Inc. brand
- B. Escutcheon Types:
 - 1. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- C. Floor Plates:
 - 1. Split Floor Plates: Cast brass with concealed hinge.

2.4 METERS AND GAUGES FOR PLUMBING PIPING

- A. Thermometers, Bimetallic Actuated, Lead Free:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc
 - b. Blue Ribbon Corp.
 - c. Ernst Flow Industries
 - d. Marsh Bellofram
 - e. Miljoco Corporation
 - f. Noshok
 - g. Palmer Wahl Instrumentation Group
 - h. REOTEMP Instrument Corporation
 - i. Tel-Tru Manufacturing Company
 - j. Trerice, H. O. Co
 - k. WATTS; A Watts Water Technologies Company
 - l. Weiss Instruments, Inc
 - m. Weksler Glass Thermometer Corp.
 - n. WIKA Instrument Corporation
 - o. Winters Instruments - U.S.
 - 2. Source Limitations: Provide lead-free bimetallic-actuated thermometers from a single manufacturer.
 - 3. Standard: ASME B40.200.
 - 4. Case: sealed type(s); stainless steel with 3-inch nominal diameter.
 - 5. Dial: Nonreflective aluminum with permanent scale markings and scales in deg F.
 - 6. Connector Type(s): Union joint, adjustable angle; with ASME B1.1 or ASME B1.20.1 screw threads to fit thermowell.
 - 7. Stem: 0.25 or 0.375 inch in diameter; stainless steel or lead-free brass.
 - 8. Window: Safety glass.
 - 9. Ring: Stainless steel.
 - 10. Element: Bimetal coil.

11. Pointer: Dark-colored metal.
 12. Accuracy: Plus or minus 1.5 percent of span.
- B. Thermowells, Lead Free:
1. Standard: ASME B40.200.
 2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 3. Material for Use with Copper Tubing: Lead-free copper.
 4. Material for Use with Steel Piping: Type 304 stainless steel.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, or as required to match threaded opening in pipe.
 7. Internal Threads: Size and thread type as required to match thermometer mounting threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length to extend a minimum of 2 inches into fluid.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing. Extension is to be of sufficient length to extend beyond finished insulation surface.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
 12. Heat-Transfer Medium: Mixture of graphite and glycerin.
- C. Pressure Gauges, Dial Type, Lead Free - Direct Mounted, Metal Case:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ametek U.S. Gauge
 - b. Ashcroft Inc
 - c. Blue Ribbon Corp.
 - d. Ernst Flow Industries
 - e. Flo Fab Inc
 - f. Marsh Bellofram
 - g. Miljoco Corporation
 - h. Noshok
 - i. Palmer Wahl Instrumentation Group
 - j. REOTEMP Instrument Corporation
 - k. Tel-Tru Manufacturing Company
 - l. Trerice, H. O. Co
 - m. WATTS; A Watts Water Technologies Company
 - n. Weiss Instruments, Inc
 - o. Weksler Glass Thermometer Corp.
 - p. WIKA Instrument Corporation
 - q. Winters Instruments - U.S.
 2. Source Limitations: Provide dial-type, lead-free, direct-mounted, metal-case pressure gauges from single manufacturer.
 3. Standard: ASME B40.100.
 4. Case: Sealed type(s);; 4-1/2-inch nominal diameter.
 5. Pressure-Element Assembly: Lead-free Bourdon tube.
 6. Pressure Connection: Lead-free brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

7. Movement: Mechanical, with link to pressure element and connection to pointer.
 8. Dial: Nonreflective aluminum with permanent scale markings graduated in psi.
 9. Pointer: Dark-colored metal.
 10. Window: Safety glass.
 11. Ring: Stainless steel.
 12. Accuracy: Grade B, plus or minus 2 percent of middle half of span.
- D. Gauge Attachments, Lead Free:
1. Snubbers: ASME B40.100, lead-free brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and-type surge-dampening device. Include extension for use on insulated piping.
 2. Valves: Lead-free brass or stainless steel needle, with, ASME B1.20.1 pipe threads.
- E. Test Plugs, Lead Free:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. IMI Flow Design, Inc.
 - b. Miljoco Corporation
 - c. Nexus Valve, Inc.; Aalberts Hydronic Flow Control
 - d. Peterson Equipment Co., Inc
 - e. Trerice, H. O. Co
 - f. WATTS; A Watts Water Technologies Company
 - g. Weiss Instruments, Inc
 - h. Weksler Glass Thermometer Corp.
 2. Source Limitations: Provide lead-free test plugs from single manufacturer.
 3. Description: Test-station fitting made for insertion into piping tee fitting.
 4. Body: Lead-free brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
 5. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
 6. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 2-inch annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout or silicone sealant, seal the space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 8413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

- A. Install sleeve with waterstop as new walls and slabs are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange centered across width of concrete slab or wall.
- C. Secure nailing flanges to wooden concrete forms.
- D. Using grout or silicone sealant, seal space around outside of sleeves. Select to maintain fire resistance of floor/slab/wall.

3.3 INSTALLATION OF STACK-SLEEVE FITTINGS

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5 INSTALLATION OF ESCUTCHEONS

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

3.6 INSTALLATION OF METERS AND GAUGES

- A. Install thermometer with thermowell at each required thermometer location.
- B. Install thermowells in vertical position in piping tees.
- C. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- D. Install thermowells with extension on insulated piping.
- E. Fill thermowells with heat-transfer medium.
- F. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- G. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks.
- H. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at most readable position.
- I. Install remote-mounted pressure gauges on panel.
- J. Install valve and snubber in piping for each pressure gauge for fluids.
- K. Install test plugs in piping tees.

- L. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlets and outlets of each domestic water heat exchanger.
 - 3. Inlet and outlet of each domestic hot-water storage tank.
 - 4. Inlet and outlet of each remote domestic water chiller.
 - 5. Outlet side of hot-water-balancing valve.
 - 6. Each main hot-water-recirculating line return pipe.
- M. Install pressure gauges in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.

3.7 CONNECTIONS

- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

3.8 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gauges to proper angle for best visibility.

3.9 FIELD QUALITY CONTROL

- A. Sleeves and Sleeve Seals:
 - 1. Perform the following tests and inspections:
 - a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
 - b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
 - 2. Prepare test and inspection reports.
- B. Escutcheons:
 - 1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.10 SLEEVES APPLICATION

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above and below Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 2. Concrete Slabs-on-Grade:
 - a. Sleeves with waterstops.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs above Grade:
 - a. Sleeves with waterstops or stack-sleeve fittings.

4. Interior Wall and Partitions:
 - a. Sleeves without waterstops.

3.11 ESCUTCHEONS APPLICATION

- A. Escutcheons for New Piping and Relocated Existing Piping:
 1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
 2. Chrome-Plated Piping: One piece, cast brass with polished, chrome-plated finish.
 3. Insulated Piping:
 - a. One piece, cast brass with polished, chrome-plated finish.
 4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
 - a. One piece, cast brass with polished, chrome-plated finish.
 5. Bare Piping at Ceiling Penetrations in Finished Spaces:
 - a. One piece, cast brass with polished, chrome-plated finish.
 6. Bare Piping in Unfinished Service Spaces:
 - a. One piece, cast brass with polished, chrome-plated finish.
 7. Bare Piping in Equipment Rooms:
 - a. One piece, cast brass with polished, chrome-plated finish.
- B. Install floor plates for piping penetrations of equipment-room floors.
- C. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 1. New Piping and Relocated Existing Piping: One piece, floor plate.
 2. Existing Piping: Split floor plate.

3.12 THERMOMETER, LEAD FREE, APPLICATION

- A. Thermometers at inlet and outlet of each domestic water heater are to be the following:
 1. Sealed, bimetallic-actuated type.
 2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.
- B. Thermometer stems are to be of length to match thermowell insertion length.

3.13 THERMOMETER, LEAD FREE, SCALE-RANGE APPLICATION

- A. Scale Range for Domestic Cold-Water Piping:
 1. 0 to 100 deg F.
- B. Scale Range for Domestic Hot-Water Piping:
 1. 0 to 250 deg F.
- C. Insert additional paragraphs for thermometer scale ranges and applications.

3.14 PRESSURE-GAUGE APPLICATION

- A. Pressure gauges at discharge of each water service into building are to be the following:
 1. Sealed, direct mounted, metal case.
 2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

- B. Pressure gauges at inlet and outlet of each water pressure-reducing valve are to be the following:
 - 1. Sealed, direct mounted, metal case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.
- C. Pressure gauges at suction and discharge of each domestic water pump are to be the following:
 - 1. Sealed, direct mounted, metal case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

3.15 PRESSURE-GAUGE SCALE-RANGE APPLICATION

- A. Scale Range for Water Service Piping:
 - 1. 0 to 200 psi.
- B. Scale Range for Domestic Water Piping:
 - 1. 0 to 160 psi.
- C. Insert additional paragraphs for pressure-gauge scale ranges and applications.

END OF SECTION 22 0500

SECTION 22 0523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ball valves.
 - 2. Check valves.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include material descriptions and dimensions of individual components.
 - b. Include operating characteristics and furnished accessories.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Standards:
 - 1. Domestic-water piping valves intended to convey or dispense water for human consumption must comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372; or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
- B. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
- C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- D. Valve Sizes: Same as upstream piping unless otherwise indicated.
- E. Valve Bypass and Drain Connections: MSS SP-45.
- F. Valve Actuator Type:
 - 1. Gear Actuator: For quarter-turn ball valves NPS 4 and larger.
 - 2. Hand Lever: For quarter-turn ball valves smaller than NPS 4.
- G. Valves in Insulated Piping:
 - 1. Provide 2-inch extended neck stems.

2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 BALL VALVES, LEAD FREE

A. Ball Valves, Lead Free, Threaded or Soldered Ends - Brass, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. American Valve, Inc
 - c. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - d. Hammond Valve
 - e. Jenkins Valves; a Crane Co. brand
 - f. Jomar Valve
 - g. KITZ Corporation
 - h. Lance Valves
 - i. Marwin Valve; Richards Industries
 - j. Milwaukee Valve Company
 - k. Red-White Valve Corp.
 - l. Stockham; a Crane Co. brand
 - m. Viega LLC
 - n. WATTS; A Watts Water Technologies Company
2. Standards: MSS SP-110 and MSS SP-145.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Forged brass.
6. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.
11. Body Design: Two piece.
12. Body Material: Forged brass.
13. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
14. Seats: PTFE.
15. Stem: Brass.
16. Ball: Chrome-plated brass.
17. Port: Full.

2.4 CHECK VALVES, LEAD FREE

A. Check Valves, Lead Free, Swing Type, Threaded or Soldered Ends - Bronze, with Bronze Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Crane Fluid Systems; Crane Co.

- c. Jenkins Valves; a Crane Co. brand
 - d. Jomar Valve
 - e. Keckley Company
 - f. Lance Valves
 - g. Milwaukee Valve Company
 - h. NIBCO INC.
 - i. Red-White Valve Corp.
 - j. Shurjoint; a part of Aalberts Integrated Piping Systems
 - k. Stockham; a Crane Co. brand
 - l. Val-Matic Valve & Manufacturing Corp.
 - m. Victaulic Company
- 2. Standard: MSS SP-80, Type 3.
 - 3. CWP Rating: 200 psig.
 - 4. Body Design: Horizontal flow.
 - 5. Body Material: ASTM B62, bronze.
 - 6. Ends: Threaded or soldered. See Part 3 check valve schedule articles.
 - 7. Disc: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.

- G. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.
- H. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves, Swing Type: In horizontal position with hinge pin level.
- I. Valve Tags: Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's written recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.

END OF SECTION 22 0523

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Pipe hangers and supports - metal.
 - 2. Pipe hangers - metal, trapeze type.
 - 3. Thermal hanger-shield inserts.
 - 4. Fastener systems.
 - 5. Pipe-positioning systems.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.

PART 2 - PRODUCTS**2.1 PIPE HANGERS AND SUPPORTS - METAL**

- A. Pipe Hangers and Supports - Carbon Steel:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. FNW; Ferguson Enterprises, Inc.
 - 2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 3. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 4. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 - 5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel stainless steel.

2.2 PIPE HANGERS - METAL, TRAPEZE TYPE

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 THERMAL HANGER-SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aeroflex USA

2. National Pipe Hanger Corporation
 3. Pipe Shields Inc.
 4. Piping Technology & Products, Inc
- B. Insulation-Insert Material for Cold Piping: minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C591, Type VI, Grade 1 polyisocyanurate with 125 psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield are to cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield are to cover bottom 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.4 FASTENER SYSTEMS

- A. Fastener System - Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities required for supported loads and building materials where used.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC
- B. Fastener System - Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities required for supported loads and building materials where used.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - e. MKT Fastening, LLC
 2. Indoor Applications: Zinc-plated or stainless steel.
 3. Outdoor Applications: Stainless steel.

2.5 PIPE-POSITIONING SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Holdrite; a division of Reliance Worldwide Corporation

- B. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- F. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 - a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches long and 0.048 inch thick.
 - b. NPS 4 (DN 100): 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches long and 0.06 inch thick.

- d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches long and 0.105 inch thick.
- 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- G. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- H. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate in accordance with ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- J. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick after concrete is placed and cured. Use installers that are licensed by powder-actuated tool manufacturer.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners in accordance with manufacturer's written instructions.
 - 3. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
 - 4. Install fasteners in accordance with manufacturer's written instructions.
- K. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- L. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

3.2 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.3 PAINTING

- A. Touchup:
 - 1. Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
 - 2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.4 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal hanger-shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

- 3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
- N. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 0529

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Warning signs and labels.
 - 2. Pipe labels.
 - 3. Valve tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS**2.1 EQUIPMENT LABELS**

- A. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation
 - 2. Craftmark Pipe Markers
 - 3. emedco
 - 4. Marking Services Inc.
 - 5. National Marker Company
 - 6. Pipemarker.com; Brimar Industries, Inc.
 - 7. Seton Identification Products; a Brady Corporation company
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

- G. Fasteners: Stainless steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation
 - 2. Craftmark Pipe Markers
 - 3. emedco
 - 4. Marking Services Inc.
 - 5. Pipemarker.com; Brimar Industries, Inc.
 - 6. Seton Identification Products; a Brady Corporation company
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation
 - 2. Craftmark Pipe Markers
 - 3. emedco
 - 4. Marking Services Inc.
 - 5. Pipemarker.com; Brimar Industries, Inc.
 - 6. Seton Identification Products; a Brady Corporation company

- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.04-inch or anodized aluminum, 0.031-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: link chain, beaded chain or S-hook.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Include valve-tag schedule in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF PIPE LABELS

- A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- B. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.

2. At access doors, manholes, and similar access points that permit view of concealed piping.
 3. Within 3 ft. of equipment items and other points of origination and termination.
 4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.
- D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- E. Flow-Direction Flow Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- F. Pipe-Label Color Schedule:
1. Domestic Cold-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 2. Domestic Hot-Water Piping: White letters on an ANSI Z535.1 safety-green background
 3. Domestic Hot-Water Return Piping White letters on an ANSI Z535.1 safety-green background.
 4. Sanitary Waste and Storm Drainage Piping: White letters on a black background.

3.4 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:
1. Valve-Tag Size and Shape:
 - a. Domestic Cold Water: 1-1/2 inches, round.
 - b. Domestic Hot Water: 1-1/2 inches, round.
 - c. Domestic Hot-Water Return: 1-1/2 inches, round.
 2. Valve-Tag Colors:
 - a. For each piping system, use the same lettering and background coloring system on valve tags as used in the piping system labels and background.

END OF SECTION 22 0553

SECTION 22 0719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Roof drains and rainwater leaders.
 - 5. Supplies and drains for handicap-accessible lavatories and sinks.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.3 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.4 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Knauf Insulation
 - c. Owens Corning
 - 2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.
 - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C547.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Owens Corning
 - c. ROCKWOOL
 - 2. Preformed Pipe Insulation: Type II, Grade A with factory-applied ASJ.
 - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.

- B. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - 2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
- C. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - 2. Adhesives shall have a VOC content of 80 g/L or less.

2.5 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
 - 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA
 - b. Childers Brand; H. B. Fuller Construction Products
 - c. Foster Brand; H. B. Fuller
 - d. Knauf Insulation
 - e. Mon-Eco Industries, Inc.
 - f. Vimasco Corporation
 - 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 3. Service Temperature Range: 0 to plus 180 deg F.

4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
5. Color: White.

2.6 LAGGING ADHESIVES

- A. Lagging Adhesives: Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Vimasco Corporation
 2. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 4. Service Temperature Range: 0 to plus 180 deg F.
 5. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - d. Owens Corning
 2. Permanently flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 58 to plus 176 deg F.
 4. Color: White or gray.
 5. Sealant shall have a VOC content of 420 g/L or less.

2.8 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division
 - b. Aeroflex USA
 - c. Avery Dennison Corporation, Specialty Tapes Division
 - d. Ideal Tape Co., Inc., an American Biltrite Company
 - e. Knauf Insulation
 - 2. Width: 3 inches.
 - 3. Thickness: 11.5 mils.
 - 4. Adhesion: 90 ounces force/inch in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch in width.
 - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.11 SECUREMENTS

- A. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Testing agency labels and stamps.
 - 2. Nameplates and data plates.
 - 3. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 5. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 6. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 7. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation conforms to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
 4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install prefabricated pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated sections of cellular-glass insulation to valve body.
 2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.

4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install prefabricated pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When prefabricated insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD QUALITY CONTROL

- A. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

- E. All insulation applications will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- C. Refer to drawings.

END OF SECTION 22 0719

SECTION 22 0800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:
 - 1. Gas-fired domestic water heaters.
 - 2. Plumbing fixtures.
- B. Related Requirements:
 - 1. Section 01 9113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. Cx: Commissioning, as defined in Section 01 9113 "General Commissioning Requirements."
- B. CxA: Commissioning Authority, as defined in Section 01 9113 "General Commissioning Requirements."
- C. IAPMO: International Association of Plumbing and Mechanical Officials.
- D. IgCC: International Green Construction Code.
- E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For plumbing testing technician.
- B. Construction Checklists:
 - 1. Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to plumbing to be part of the Cx process and in accordance with requirements in Section 01 9113 "General Commissioning Requirements", IAPMO "Green Plumbing and Mechanical Code Supplement," and ASHRAE 202.

1.4 QUALITY ASSURANCE

- A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing Construction Checklist verification tests. Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of plumbing system, electrical concepts, and building operations.
 - 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. Testing Equipment and Instrumentation Quality and Calibration:
 - 1. Capable of testing and measuring performance within the specified acceptance criteria.
 - 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 - 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform Cx process for plumbing systems in accordance with:
 - 1. ASHRAE 202.

3.2 CONSTRUCTION CHECKLISTS

- A. Prepare preliminary detailed construction checklists for each plumbing system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in ASHRAE 202.
 - 1. Submit preliminary construction checklists to CxA and Designer for review.
 - 2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 3. Use only construction checklists marked "Approved for Use, (date)." Mark construction checklists in the appropriate place as indicated Project events are completed and provide pertinent details and other information.
 - 4. Domestic hot-water systems and controls.
- B. Additional Systems Required to Be Commissioned:
 - 1. Domestic water piping, including the following:
 - a. Meters and gauges.
 - 2. Plumbing fixtures, including the following:
 - a. Water closets, supports and connections, supplies, and flush valves.
 - b. Lavatories, supports, supplies, drain connections, faucets, and mixing valves.

- c. Sinks, supports, supplies, drain connections, faucets, and mixing valves.
- d. Water Filter Units, supplies, filters, and filter status monitoring.

3.3 Cx TESTING PREPARATION

- A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that plumbing system instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and that all systems are set to and maintaining set points as required by the design documents.
- C. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

3.5 Cx TESTS COMMON TO PLUMBING SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response compared to acceptance criteria.

- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 22 Sections specifying plumbing systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

END OF SECTION 22 0800

SECTION 22 1116 - DOMESTIC WATER PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Copper tube and fittings - domestic water.
 2. Piping joining materials - domestic water.
 3. Dielectric fittings - domestic water.

1.2 ACTION SUBMITTALS

- A. Product Data:
1. Copper tube and fittings - domestic water.
 2. Piping joining materials - domestic water.
 3. Transition fittings - domestic water.
 4. Dielectric fittings - domestic water.

1.3 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service in accordance with requirements indicated:
1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
 2. Do not interrupt water service without Owner's written permission.

1.4 WARRANTY

- A. Polypropylene (PP-R and PP-RCT) Pipe and Fittings Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R and PP-RCT pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of piping system due to defects in materials or manufacturing.
 2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system was tested and passed manufacturer's pressure/leak test.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Domestic water piping, tubing, fittings, joints, and appurtenances intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act, with requirements of authorities having jurisdiction, and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PIPING MATERIALS

- A. Potable-water piping and components are to comply with NSF 14, NSF 61, and NSF 372. Include marking "NSF-pw" on piping.

2.3 COPPER TUBE AND FITTINGS - DOMESTIC WATER

- A. Drawn-Temper Copper Tube: ASTM B88, Type K ASTM B88, Type L.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cambridge-Lee Industries, LLC
 - b. Cerro Flow Products, LLC
 - c. Mueller Streamline Co.; a company of Mueller Industries
- B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems
 - b. Mueller Streamline Co.; a company of Mueller Industries
 - c. NIBCO INC.
- C. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than NPS 4.
- D. Wrought Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.

2.4 PIPING JOINING MATERIALS - DOMESTIC WATER

- A. Pipe-Flange Gasket Materials:
 - 1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 - 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B32, lead-free alloys.

- D. Flux: ASTM B813, water flushable.
- E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 TRANSITION FITTINGS - DOMESTIC WATER

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.6 DIELECTRIC FITTINGS - DOMESTIC WATER

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions - Domestic Water:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. HART Industrial Unions, LLC
 - d. Jomar Valve
 - e. Matco-Norca
 - f. WATTS; A Watts Water Technologies Company
 - g. Zurn Industries, LLC
 - 2. Source Limitations: Obtain dielectric unions from single manufacturer.
 - 3. Standard: ASSE 1079.
 - 4. Pressure Rating: 150 psig.
 - 5. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Nipples - Domestic Water:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. Matco-Norca
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. Victaulic Company
 - 2. Source Limitations: Obtain dielectric nipples from single manufacturer.
 - 3. Standard: IAPMO PS 66.
 - 4. Electroplated steel nipple complying with ASTM F1545.
 - 5. Pressure Rating and Temperature: 300 psig at 225 deg F.
 - 6. End Connections: Male threaded or grooved.
 - 7. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION**3.1 PIPING APPLICATIONS**

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Refer to drawings.

3.2 EARTHWORK

- A. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab in accordance with CDA's "Copper Tube Handbook."
- C. Install valves in accordance with Section 22 0523 "General-Duty Valves for Plumbing Piping."
- D. Install domestic water piping level without pitch and plumb.
- E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- H. Install piping to permit valve servicing.

- I. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- J. Install piping free of sags and bends.
- K. Install fittings for changes in direction and branch connections.
- L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 0500 "Common Work Results for Plumbing."
- M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 0500 "Common Work Results for Plumbing."
- N. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 0500 "Common Work Results for Plumbing."

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Braze Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings in accordance with ASTM B828 or CDA's "Copper Tube Handbook."
- F. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.5 INSTALLATION OF TRANSITION FITTINGS

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.

2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

3.6 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for hangers, supports, and anchor devices in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Support horizontal piping within 12 inches of each fitting.

3.8 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

3.9 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.10 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system in accordance with either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

- 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 ADJUSTING

- A. Perform the following adjustments before operation:
1. Close drain valves, hydrants, and hose bibbs.
 2. Open shutoff valves to fully open position.
 3. Open throttling valves to proper setting.
 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
 8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.12 FIELD QUALITY CONTROL

- A. Tests and Inspections:
1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after installation and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

- d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- 2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Hydrostatic testing and documentation of test results for polypropylene (PP-R and PP-RCT) pipe to be in accordance with manufacturer's written instructions and submitted to manufacturer upon successful completion per warranty requirements.
 - f. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - g. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 22 1116

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Vacuum breakers.
 - 2. Temperature-actuated, water mixing valves.
 - 3. Wall hydrants.
 - 4. Water-hammer arresters.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.
 - 1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Test and inspection reports.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Cash Acme Plumbing Products; an RWC brand
 - c. FEBCO; A WATTS Brand

- d. WATTS; A Watts Water Technologies Company
 - e. Zurn Industries, LLC
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Cash Acme Plumbing Products; an RWC brand
 - c. Champion-Arrowhead
 - d. Jay R. Smith Mfg Co; a division of Morris Group International
 - e. MIFAB, Inc
 - f. WATTS; A Watts Water Technologies Company
 - g. Woodford Manufacturing Company
 - h. Zurn Industries, LLC
 - 2. Standard: ASSE 1011.
 - 3. Body: Bronze, nonremovable, with manual drain.
 - 4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 - 5. Finish: Chrome or nickel plated.

2.3 TEMPERATURE-ACTUATED, WATER MIXING VALVES

- A. Individual-Fixture, Water Tempering Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Caleffi North America
 - b. Lawler Manufacturing Company, Inc
 - c. POWERS; A Watts Water Technologies Company
 - d. Zurn Industries, LLC
 - e. Bradley Corp.
 - 2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
 - 3. Pressure Rating: 125 psig minimum unless otherwise indicated.
 - 4. Material: Bronze body with corrosion-resistant interior components.
 - 5. Temperature Control: Adjustable.
 - 6. Connections: Threaded inlets and outlet.
 - 7. Finish: Chrome plated.
 - 8. Tempered-Water Setting: 110 deg F.

2.4 WALL HYDRANTS

- A. Nonfreeze Vacuum Breaker Wall Hydrants:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Champion-Arrowhead
 - c. Jay R. Smith Mfg Co; a division of Morris Group International

- d. Prier Products, Inc.
- e. WATTS; A Watts Water Technologies Company
- f. Woodford Manufacturing Company
- g. Zurn Industries, LLC
2. Standard: ASSE 1019, Type A or Type B.
3. Type: Automatic draining with integral air-inlet valve.
4. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: 125 psig.
6. Operation: Loose key.
7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: NPS 1/2 or NPS 3/4.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.5 WATER-HAMMER ARRESTERS

- A. Water-Hammer Arresters:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Jay R. Smith Mfg Co; a division of Morris Group International
 - c. Josam Company
 - d. MIFAB, Inc
 - e. Precision Plumbing Products
 - f. ProFlo; a Ferguson Enterprises, Inc. brand
 - g. Sioux Chief Manufacturing Company, Inc.
 - h. WATTS; A Watts Water Technologies Company
 - i. Zurn Industries, LLC
 2. Standard: ASSE 1010 or PDI-WH 201.
 3. Type: Piston.
 4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Backflow Preventers: Install in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 1. Locate backflow preventers in same room as connected equipment or system.
 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 3. Do not install bypass piping around backflow preventers.
- B. Water Regulators: Install with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gauges on inlet and outlet.

- C. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.
- D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- E. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.
- F. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- G. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.
- H. Trap-Seal Primer Systems: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.3 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 22 1119

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hubless, cast-iron soil pipe and fittings.
 - 2. PVC pipe and fittings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 FIELD CONDITIONS

- A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service in accordance with requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
 - 2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

1.4 WARRANTY

- A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Piping materials to bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AB & I Foundry; a part of the McWane family of companies
 - 2. Charlotte Pipe and Foundry Company
 - 3. Tyler Pipe; a part of the McWane family of companies
- B. Pipe and Fittings:
 - 1. Marked with CISPI collective trademark.

2. ASTM A888 or CISPI 301.

C. Heavy-Duty, Hubless-Piping Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AB & I Foundry; a part of the McWane family of companies
 - b. ANACO-Husky; a part of the McWane family of companies
 - c. Charlotte Pipe and Foundry Company
 - d. Clamp-All Corp
 - e. Dallas Specialty & Mfg. Co.
 - f. Ideal Tridon Group
 - g. MIFAB, Inc
 - h. Mission Rubber Company, LLC
 - i. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C1277 and ASTM C1540.
3. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Apollo Valves; a part of Aalberts Integrated Piping Systems
 2. Charlotte Pipe and Foundry Company
 3. GF Piping Systems
 4. JM Eagle
 5. National Pipe and Plastic, Inc. (Oldcastle)
 6. North America Pipe Corporation
 7. Rocky Mountain Colby Pipe Company
 8. Silver-line Plastics
- B. Comply with NSF 14 for plastic piping components. Include "NSF-dwv" marking for plastic drain, waste, and vent piping and "NSF-sewer" marking for plastic sewer piping.
- C. Solid-Wall PVC Pipe: ASTM D2665 drain, waste, and vent.
- D. Cellular-Core PVC Pipe: ASTM F891, Schedule 40.
- E. PVC Socket Fittings: ASTM D2665, made in accordance with ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- F. Adhesive Primer: ASTM F656.
1. Product Data: Verify adhesive primer has a VOC content of 550 g/L or less.
- G. Solvent Cement: ASTM D2564.
1. Product Data: Verify PVC welding solvent cement has a VOC content of 510 g/L or less.

PART 3 - EXECUTION**3.1 EARTH MOVING**

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 - 2. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
 - 1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
 - 2. Use long-turn, double Y-branch, and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
 - a. Straight tees, elbows, and crosses may be used on vent lines.
 - 3. Do not change direction of flow more than 90 degrees.
 - 4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of waste piping in direction of flow is prohibited.

- K. Lay buried building waste piping beginning at low point of each system.
 - 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 - 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 - 3. Maintain swab in piping and pull past each joint as completed.
- L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Waste: Two percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.
- M. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping in accordance with ASTM A674 or AWWA C105/A 21.5.
- N. Install steel piping in accordance with applicable plumbing code.
- O. Install underground PVC piping in accordance with ASTM D2321.
- P. Install engineered soil and waste and vent piping systems as follows:
 - 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 - 2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
 - 3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
- Q. Install underground, ductile-iron, force-main piping according to AWWA C600.
 - 1. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints.
 - 2. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 - 3. Install encasement on piping in accordance with ASTM A674 or AWWA C105/A 21.5.
- R. Install underground, copper, force-main tubing in accordance with CDA's "Copper Tube Handbook."
 - 1. Install encasement on piping in accordance with ASTM A674 or AWWA C105/A 21.5.
- S. Install force mains at elevations indicated.
- T. Plumbing Specialties:
 - 1. Install backwater valves in sanitary waster gravity-flow piping.
 - a. Comply with requirements for backwater valves specified in Section 22 1319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
 - a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
 - b. Comply with requirements for cleanouts specified in Section 22 1319 "Sanitary Waste Piping Specialties."
3. Install drains in sanitary waste gravity-flow piping.
 - a. Comply with requirements for drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
- U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- V. Install sleeves for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for sleeves specified in Section 22 0500 "Common Work Results for Plumbing."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs.
 1. Comply with requirements for sleeve seals specified in Section 22 0500 "Common Work Results for Plumbing."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for escutcheons specified in Section 22 0500 "Common Work Results for Plumbing."

3.3 JOINT CONSTRUCTION

- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.
- C. Hubless, Cast-Iron Soil Piping Coupled Joints:
 1. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.
 1. Cut threads full and clean using sharp dies.
 2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - c. Do not use pipe sections that have cracked or open welds.
- E. Join stainless steel pipe and fittings with gaskets in accordance with ASME A112.3.1.

- F. Join copper tube and fittings with soldered joints in accordance with ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.
- G. Grooved Joints: Cut groove ends of pipe in accordance with AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
- I. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join in accordance with ASTM D2235 and ASTM D2661 appendixes.
 - 3. PVC Piping: Join in accordance with ASTM D2855 and ASTM D2665 appendixes.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment".
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 3. Vertical Piping: MSS Type 8 or Type 42 clamps.
 - 4. Install individual, straight, horizontal piping runs:
 - a. 100 Ft. (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Ft. (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Ft. (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 5. Multiple, Straight, Horizontal Piping Runs 100 Ft. (30 m) or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze.
- B. Install hangers for PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- C. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- D. Support vertical runs of cast-iron soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

- E. Support vertical runs of PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect waste and vent piping to the following:
 - 1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Install horizontal backwater valves with cleanout cover flush with floor.
 - 6. Equipment: Connect waste piping as indicated.
 - a. Provide shutoff valve if indicated and union for each connection.
 - b. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.6 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.
- B. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.7 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Exposed Plastic Piping: Protect PVC plumbing vents exposed to sunlight with two coats of water-based latex paint.
- E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.8 PIPING SCHEDULE

- A. Refer to drawings.

END OF SECTION 22 1316

SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cleanouts.
 - 2. Miscellaneous sanitary drainage piping specialties.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show fabrication and installation details for frost-resistant vent terminals.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

- A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 CLEANOUTS

- A. Cast-Iron Exposed Cleanouts (Insert drawing designation, if any):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Josam Company
 - c. MIFAB, Inc
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. WATTS; A Watts Water Technologies Company
 - f. Zurn Industries, LLC
 - 2. Standard: ASME A112.36.2M.
 - 3. Size: Same as connected drainage piping

4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure: Countersunk, plug.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
- B. Cast-Iron Wall Cleanouts (Insert drawing designation, if any):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Josam Company
 - c. MIFAB, Inc
 - d. WATTS; A Watts Water Technologies Company
 - e. Zurn Industries, LLC
 2. Standard: ASME A112.36.2M. Include wall access.
 3. Size: Same as connected drainage piping.
 4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure Plug:
 - a. Brass Cast iron.
 - b. Countersunk head.
 - c. Drilled and threaded for cover attachment screw.
 - d. Size: Same as or not more than one size smaller than cleanout size.
 6. Wall Access, Cover Plate: Round, flat, chrome-plated brass or stainless steel cover plate with screw.
 7. Wall Access, Frame and Cover: Round, wall-installation frame and cover.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

- A. Floor-Drain, Trap-Seal Primer Fittings:
1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
 2. Size: Same as floor drain outlet with NPS 1/2 side inlet.
- B. Floor-Drain, Inline Trap Seal (Insert drawing designation, if any):
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Green Drain, Inc.
 - b. Jay R. Smith Mfg Co; a division of Morris Group International
 - c. Josam Company
 - d. MIFAB, Inc
 - e. RectorSeal Plumbing; A CSW Industrials Company
 2. Description: Inline floor drain trap seal, forming a physical barrier to slow trap evaporation while not impeding flow from drain.
 3. Material: Polymer.
 4. Standard: Tested and certified in accordance with ASSE 1072.
 5. Listing: ICC-ES or IAPMO listed.
 6. Size: Same as floor drain outlet or strainer throat.

- C. Vent Caps:
 - 1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
 - 2. Size: Same as connected stack vent or vent stack.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backwater valves in building drain piping.
 - 1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- F. Install vent caps on each vent pipe passing through roof.
- G. Install wood-blocking reinforcement for wall-mounting-type specialties.
- H. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 PIPING CONNECTIONS

- A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
 - 1. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1319

SECTION 22 1319.13 - SANITARY DRAINS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Floor drains.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.

PART 2 - PRODUCTS**2.1 DRAIN ASSEMBLIES**

- A. Sanitary drains are to bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains (Insert drawing designation if any):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Josam Company
 - c. MIFAB, Inc
 - d. Wade; a subsidiary of McWane Inc.
 - e. WATTS; A Watts Water Technologies Company
 - f. Zurn Industries, LLC
 - 2. Source Limitations: Obtain cast-iron floor drains from single manufacturer.
 - 3. Standard: ASME A112.6.3
 - 4. Pattern: Floor drain.
 - 5. Body Material: Gray iron.
 - 6. Outlet: Bottom.
 - 7. Top or Strainer Material: Nickel bronze.
 - 8. Top of Body and Strainer Finish: Nickel bronze.
 - 9. Top Shape: Square.

PART 3 - EXECUTION**3.1 INSTALLATION OF SANITARY DRAINS**

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.

2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1319.13

SECTION 22 3400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.4 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - d. Storage Tank: 25-year coverage (15 years full, 10 additional years of discounted replacement) for manufacturing or material defects, leaks, production of rusty or discolored water and/or chloride stress corrosion cracking.
 - e. Heat exchanger: 10-year coverage for manufacturing or material defects, leaks, and/or the production of rusty water (5 years full, 5 additional years of discounted replacement). Full portion of the warranty includes the replacement exchanger, labor and freight.
 - f. External economizer: 1 year.
 - g. Burner and all heater parts: 1 year
 - h. The heater shall have a first year service policy, which shall cover labor and freight costs under certain conditions for warranty covered

- i. Expansion Tanks: Five years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. ASHRAE/IES Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IES 90.1.
 - 1. Comply with efficiency requirements in ASHRAE 189.1, which supersede requirements in ASHRAE/IESNA 90.1.
- C. ASME Compliance:
 - 1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

2.2 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

- A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A. O. Smith Corporation
 - b. AERCO; A WATTS Brand
 - c. PVI; A WATTS Brand
 - 2. Source Limitations: Obtain domestic-water heaters from single source from single manufacturer.
 - 3. Standard: ANSI Z21.10.3/CSA 4.3.
 - 4. Description: Manufacturer's proprietary design to provide at least 96 percent combustion efficiency at optimum operating conditions.
 - 5. Storage-Tank Construction: ASME-code steel with 150-psig minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.

6. The storage tank shall be an unlined pressure vessel constructed from phase-balanced austenitic and ferritic duplex steel with a chemical structure containing a minimum of 21% chromium to prevent corrosion and mill certified per ASTM A 923 Methods A to ensure that the product is free of detrimental chemical precipitation that affects corrosion resistance.
 - a. The material selected shall be tested and certified to pass stress chloride cracking test protocols as defined in ISO 3651-2 and ASTM G123 - 00(2005) "Standard Test Method for Evaluating Stress-Corrosion Cracking of Stainless Alloys with Different Nickel Content in Boiling Acidified Sodium Chloride Solution."
 7. Waterside surfaces shall be welded internally utilizing joint designs to minimize volume of weld deposit and heat input. All heat affected zones (HAZ) shall be processed after welding to ensure the HAZ corrosion resistance is consistent with the mill condition base metal chemical composition. Weld procedures (amperage, volts, welding speed, filler metals and shielding gases) utilized shall result in a narrow range of austenite-ferrite microstructure content consistent with phase balanced objectives for welds, HAZ and the base metal.
 8. All internal and external tank surfaces shall undergo full immersion passivation and pickling processing to meet critical temperature, duration and chemical concentration controls required to complete corrosion resistance restoration of pressure vessel surfaces. Other passivation and pickling methods are not accepted. Immersion passivation and pickling certification documents are required and shall be provided with each product. PV 8821 8-2022 G. Materials shall meet ASME Section II material requirements and be accepted by NSF 61 for municipal potable water systems. Storage tank materials shall contain more than 80% postconsumer recycled materials and be 100% recyclable. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE/IES 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
 - g. Temperature Control: Adjustable thermostat.
 - h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
- B. Capacity and Characteristics:
1. Capacity: 575 gallon
 2. Recovery: 1175 gph at 100 deg F temperature rise.
 3. Temperature Setting: 125 deg F.

4. Fuel Gas Demand: 1000 cfh.
5. Fuel Gas Input: 1,000,000 Btu/h.
6. Electrical Characteristics:
 - a. Volts: 120 V.
 - b. Phase: Single.
 - c. Hertz: 60 Hz.
 - d. Minimum Circuit Ampacity: 11 A.
7. Minimum Vent Diameter: 6 inches.

2.3 DOMESTIC-WATER HEATER ACCESSORIES

- A. Domestic-Water Expansion Tanks:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Wessels
 - c. Bell and Gossett
 2. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.
 3. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber bladder. Include air precharge to minimum system-operating pressure at tank.
 4. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
 5. Capacity and Characteristics:
 - a. Working-Pressure Rating: 150 psig.
 - b. Full acceptance bladder: 35 gallon minimum.
- B. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 22 0523 "General-Duty Valves for Plumbing Piping."
 1. Comply with requirements for balancing valves specified in Section 22 1119 "Domestic Water Piping Specialties."
- C. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1, manually operated. Furnish for installation in piping.
- D. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

- E. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
 - 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4.
 - 2. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEATER

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 8. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 0523 "General-Duty Valves for Plumbing Piping."

- C. Install gas-fired, domestic-water heaters in accordance with NFPA 54.
 - 1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 - 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 - 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 - 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves.
- D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 22 1119 "Domestic Water Piping Specialties."
- F. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 22 0500 "Common Work Results for Plumbing."
- G. Fill domestic-water heaters with water.
- H. Charge domestic-water expansion tanks with air to required system pressure.
- I. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Section 22 1116 "Domestic Water Piping."
- B. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters. Training shall be a minimum of 4 hour(s).

END OF SECTION 22 3400

SECTION 22 4200 - COMMERCIAL PLUMBING FIXTURES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Commercial lavatories.
 - 2. Commercial sinks.
 - 3. Commercial water closets.
 - 4. Flushometer valves.
 - 5. Toilet seats.
 - 6. Fixture carriers.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Include construction details, material descriptions and thicknesses, dimensions of individual components and profiles, and finishes for plumbing fixtures.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each product provided.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Lavatory faucets and sink faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 and NSF 372, or be certified in compliance with NSF 61 and NSF 372 by an ANSI-accredited third-party certification body, in that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 COMMERCIAL LAVATORIES

- A. Lavatories, Wall Mounted (LAV-1):
 - 1. Lavatories, Wall Mounted - Vitreous China, Rectangular with Back:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) American Standard
 - 2) Kohler Co
 - 3) Sloan Valve Company
 - 4) Zurn Industries, LLC
 - b. Fixture:
 - 1) Standard: ASME A112.19.2/CSA B45.1.

- 2) Type: For wall hanging.
 - 3) Nominal Size: Rectangular, 20 by 18 inches.
 - 4) Faucet-Hole Punching: Three holes, 4-inch centers.
 - 5) Faucet-Hole Location: Top.
 - 6) Color: White.
 - 7) Mounting Material: Chair carrier.
 - c. Support: Lavatory carrier, floor affixed with steel uprights.
 - d. Lavatory Mounting Height: Accessible in accordance with ICC A117.1.
- B. Lavatory Faucets, Manually Operated:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard
 - b. Chicago Faucets; Geberit Group
 - c. Kohler Co
 - d. T&S Brass and Bronze Works, Inc.
 - e. Zurn Industries, LLC
 - 2. Standard: ASME A112.18.1/CSA B125.1.
 - 3. Operation Type: Two handle, mixing, Commercial.
 - 4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 - 5. Body Type: Centerset.
 - 6. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 - 7. Finish: Polished chrome plate.
 - 8. Maximum Flow Rate: 0.5 gpm.
 - 9. Mounting Type: Deck, exposed.
 - 10. Valve Handle(s): Wrist blade, 4 inches.
 - 11. Spout: Rigid type.
 - 12. Spout Outlet: Spray.
 - 13. Operation: Compression, manual.
- C. Lavatory Supply Fittings:
- 1. NSF Standards: Comply with NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
 - 2. Standard: ASME A112.18.1/CSA B125.1.
 - 3. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.
 - 4. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
 - 5. Operation: Loose key.
 - a. Risers Size: NPS 3/8.
 - b. Risers Material: ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel, flexible hose.
- D. Lavatory Waste Fittings:
- 1. Standard: ASME A112.18.2/CSA B125.2.
 - 2. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

3. Trap:
 - a. Size: NPS 1-1/2 by NPS 1-1/4.
 - b. Material:
 - 1) Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated, brass or steel wall flange.

2.3 COMMERCIAL SINKS

- A. Counter Mounted Sinks (S-1):
 1. Single Bowl Sink, Counter Mounted - Stainless Steel:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elkay
 - 2) Just Manufacturing
 - b. Source Limitations: Obtain sinks from single source from single manufacturer.
 - c. Fixture:
 - 1) Standard: ASME A112.19.3/CSA B45.4.
 - 2) Type: Stainless steel, self-rimming, sound-deadened unit less ledge back.
 - 3) Number of Compartments: One.
 - 4) Material: 18-gauge, Type 304 stainless steel.
 - d. Mounting: On counter with sealant.
 2. Sink Faucets, Manually Operated:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Chicago Faucets; Geberit Group
 - 2) Elkay.
 - 3) Just Manufacturing
 - 4) Kohler Co
 - 5) T&S Brass and Bronze Works, Inc.
 - 6) Zurn Industries, LLC
 - b. Faucet: Cast brass, manually operated, 8" gooseneck, 1.5 gpm, deck mounted and wrist blade handles.
 - 1) Number Required: One.
 - 2) Mounting: On ledge.
 - c. Supply Fittings:
 - 1) Standard: ASME A112.18.1/CSA B125.1.
 - 2) Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.
 - a) Operation: Loose key.
 - b) Risers: NPS 1/2, ASME A112.18.6/CSA B125.6, braided or corrugated stainless steel flexible hose.
 3. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Trap(s) Size: NPS 1-1/2.
 - c. Trap(s) Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 17-gauge brass tube to wall.

2.4 COMMERCIAL WATER CLOSETS

- A. Water Closets, Wall Mounted (WC-1):
1. Water Closets, Wall Mounted - Back Outlet, Top Spud:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) American Standard
 - 2) Kohler Co
 - 3) Zurn Industries, LLC
 - b. Source Limitations: Obtain water closets from single source from single manufacturer.
 - c. Standard: ASME A112.19.2/CSA B45.1.
 - d. Bowl:
 - 1) Material: Vitreous china.
 - 2) Type: Siphon jet.
 - 3) Style: Flushometer valve.
 - 4) Height: Accessible in accordance with ICC A117.1.
 - 5) Rim Contour: Elongated.
 - 6) Water Consumption: 1.28 gal. per flush.
 - 7) Spud Size and Location: NPS 1-1/2; top.
 - 8) Color: White.

2.5 FLUSHOMETER VALVES

- A. Flushometer Valves, Manually Operated - Piston, Lever Handle:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard
 - b. Kohler Co
 - c. Sloan Valve Company
 - d. Zurn Industries, LLC
 2. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
 3. Standard: ASSE 1037/ASME 112.1037/CSA B125.37.
 4. Minimum Pressure Rating: 125 psig.
 5. Features: Include integral check stop and backflow-prevention device.
 6. Material: Brass body with corrosion-resistant components.
 7. Style: Exposed.
 8. Flushometer-Valve Finish: Chrome-plated.
 9. Handle Finish: Chrome-plated.
 10. Consumption: 1.28 gal. per flush.
 11. Minimum Inlet: NPS 1.

2.6 TOILET SEATS

- A. Toilet Seats - Commercial:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard
 - b. Bemis Manufacturing Company

- c. Centoco Manufacturing Corporation
- d. Church Seats; Bemis Manufacturing Company
- e. Kohler Co
- f. Zurn Industries, LLC
2. Source Limitations: Obtain toilet seat from single source from single manufacturer.
3. Standard: IAPMO/ANSI Z124.5.
4. Material: Plastic.
5. Type: Commercial (heavy duty).
6. Shape: Elongated rim, open front.
7. Hinge: Self-sustaining, check.
8. Hinge Material: Noncorroding metal.
9. Seat Cover: Not required.
10. Color: White.
11. Surface Treatment: Antimicrobial.

2.7 FIXTURE CARRIERS

A. Fixture Carriers - Lavatory:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. Josam Company
 - c. MIFAB, Inc
 - d. Wade; a subsidiary of McWane Inc.
 - e. WATTS; A Watts Water Technologies Company
 - f. Zurn Industries, LLC
2. Source Limitations: Obtain lavatory carriers from single source from single manufacturer.
3. Standards:
 - a. ASME A112.6.1M.
 - b. ASME A112.6.2.

B. Fixture Carriers - Water Closet:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International
 - b. MIFAB, Inc
 - c. Wade; a subsidiary of McWane Inc.
 - d. WATTS; A Watts Water Technologies Company
 - e. Zurn Industries, LLC
2. Source Limitations: Obtain water closet carriers from single source from single manufacturer.
3. Standard: ASME A112.6.1M.
4. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings, gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine roughing-in of water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine walls and floors for suitable conditions where plumbing fixtures will be installed.
- C. Examine counters for suitable conditions where lavatories and sinks will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF COMMERCIAL PLUMBING FIXTURES

- A. Lavatory Installation:
 - 1. Install lavatories level and plumb in accordance with roughing-in drawings.
 - 2. Install supports, affixed to building substrate, for wall-mounted lavatories.
 - 3. Install accessible, wall-mounted lavatories at mounting height in accordance with ICC A117.1.
 - 4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
 - 5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
 - 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 0500 "Common Work Results for Plumbing."
 - 7. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."
 - 8. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories.
- B. Sink Installation:
 - 1. Install sinks level and plumb in accordance with roughing-in drawings.
 - 2. Install water-supply piping with stop on each supply to each sink faucet.
 - a. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 22 0523 "General Duty Valves for Plumbing Piping."
 - b. Install stops/valves in locations that are accessible for ease of operation.
 - 3. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
 - 4. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 0500 "Common Work Results for Plumbing."

5. Seal joints between sinks, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."
- C. Water Closet Installation:
 1. Install water closets level and plumb in accordance with roughing-in drawings.
 2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
 3. Install flushometer-valve, water-supply fitting on each supply to each water closet.
 4. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
 5. Install actuators in locations easily reachable for people with disabilities.
 6. Install toilet seats on water closets.
 7. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 0500 "Common Work Results for Plumbing."
 8. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."

3.3 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning plumbing fixtures, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Adjust water pressure at flushometer valves to produce proper flow.

3.4 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damage to finishes. Replace any fixtures unable to be repaired to the satisfaction of the Owner.
- B. Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 4200

SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Motors.
 2. Sleeves without waterstop.
 3. Sleeves with waterstop.
 4. Grout.
 5. Silicone sealants.
 6. Thermometers, liquid in glass.
 7. Thermowells.
 8. Pressure gauges, dial type.
 9. Gauge attachments.
 10. Test plugs.
 11. Sight flow indicators.
 12. Flowmeters.

1.2 ACTION SUBMITTALS

- A. Product Data:
1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
1. Motor controllers.
 2. Torque, speed, and horsepower requirements of the load.
 3. Ratings and characteristics of supply circuit and required control sequence.
 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 MOTORS**

- A. Motor Requirements, General:
1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
 2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
 3. Comply with NEMA MG 1 unless otherwise indicated.

- B. Motor Characteristics:
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 ft. above sea level.
 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- C. Polyphase Motors:
1. Description: NEMA MG 1, Design B, medium induction motor.
 2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
 3. Service Factor: 1.15.
 4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
 5. Rotor: Random-wound, squirrel cage.
 6. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
 7. Temperature Rise: Match insulation rating.
 8. Insulation: Class F.
 9. Code Letter Designation:
 - a. Motors 15 Hp and Larger: NEMA starting Code F or Code G.
 - b. Motors Smaller Than 15 Hp: Manufacturer's standard starting characteristic.
 10. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- D. Additional Requirements for Polyphase Motors:
1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
 2. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.
 - b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- E. Single-Phase Motors:
1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
 4. Motors 1/20 hp and Smaller: Shaded-pole type.
 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.
- F. Electronically Commutated Motors:
1. Microprocessor-Based Electronic Control Module: Converts 120 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
 2. Three-phase power motor module with permanent magnet rotor.
 3. Circuit board or digital speed controller/LED display.
 4. Building Automation System Interface: Via DC voltage signal.

2.2 SLEEVES AND SLEEVE SEALS

- A. Sleeves without Waterstop:
1. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.
 2. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
 3. Steel Sheet Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
- B. Grout:
1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
 2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 3. Design Mix: 5000 psi, 28-day compressive strength.
 4. Packaging: Premixed and factory packaged.
- C. Silicone Sealants:
1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
 2. Standard: Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.

2.3 METERS AND GAUGES FOR HVAC PIPING

- A. Thermometers, Liquid in Glass - Metal Case, Industrial Style:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation
 - b. Terice, H. O. Co
 - c. Weiss Instruments, Inc
 2. Source Limitations: Provide liquid-in-glass, metal-case, industrial-style thermometers from single manufacturer.
 3. Standard: ASME B40.200.
 4. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.

5. Case Form: Adjustable angle unless otherwise indicated.
 6. Tube: Glass with magnifying lens and blue or red organic liquid.
 7. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
 8. Window: Glass or plastic.
 9. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
 10. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
 11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- B. Thermowells:
1. Standard: ASME B40.200.
 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
 3. Material for Use with Copper Tubing: CNR or CUNI.
 4. Material for Use with Steel Piping: CRES or CSA.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
 7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length required to match thermometer bulb or stem.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
 12. Heat-Transfer Medium: Mixture of graphite and glycerin.
- C. Gauge Attachments:
1. Coordinate attachment size in this article with pressure-gauge-connection size.
 2. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
 3. Siphons: Loop-shaped section of brass pipe with NPS 1/4 or NPS 1/2 pipe threads.
 4. Valves: Brass or stainless steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Using grout or silicone sealant, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.
- B. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.
- C. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 8413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES - GENERAL

- A. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 8413 "Penetration Firestopping."

END OF SECTION 23 0500

SECTION 23 0523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene-diene monomer.
- C. NBR: Nitrile butadiene rubber (also known as "Buna-N").
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. PTFE: Polytetrafluoroethylene.
- G. RS: Rising stem.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. Set butterfly valves closed or slightly open.
 - 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. ASME Compliance:
1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.5 for flanges on steel valves.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B16.18 for cast-copper solder-joint connections.
 5. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
 6. ASME B16.34 for flanged- and threaded-end connections.
- B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Bypass and Drain Connections: MSS SP-45.
- G. Valve Actuator Type:
1. Hand Lever: For quarter-turn ball valves smaller than NPS 4.
- H. Valves in Insulated Piping:
1. Provide 2-inch extended neck stems.
 2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 BALL VALVES

- A. Ball Valves, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Bronze or Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Crane Fluid Systems; Crane Co.
 - c. Hammond Valve
 - d. Jenkins Valves; a Crane Co. brand
 - e. Milwaukee Valve Company

- f. NIBCO INC.
- g. Red-White Valve Corp.
- h. Zurn Industries, LLC
- 2. Standard: MSS SP-110.
- 3. SWP Rating: 150 psig.
- 4. CWP Rating: 600 psig.
- 5. Body Design: Two piece.
- 6. Body Material: Bronze.
- 7. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
- 8. Seats: PTFE.
- 9. Stem: Bronze.
- 10. Ball: Chrome-plated brass.
- 11. Port: Full.

2.4 BUTTERFLY VALVES

- A. Butterfly Valves, Single Flange (Lug Type) - Iron, with Aluminum-Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Hammond Valve
 - c. Jenkins Valves; a Crane Co. brand
 - d. Legend Valve & Fitting, Inc
 - e. Milwaukee Valve Company
 - f. NIBCO INC.
 - g. Red-White Valve Corp.
 - h. Viega LLC
 - i. Zurn Industries, LLC
 - 2. Standard: MSS SP-67, Type I.
 - 3. CWP Rating: 150 psig or 200 psig. See Part 3 butterfly valve schedule articles.
 - 4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - 5. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - 6. Seat: EPDM or NBR. See Part 3 butterfly valve schedule articles.
 - 7. Stem: One- or two-piece stainless steel.
 - 8. Disc: Aluminum bronze.
- B. Butterfly Valves, Grooved End - Ductile Iron, 175 CWP:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Hammond Valve
 - c. NIBCO INC.
 - d. Red-White Valve Corp.
 - e. Victaulic Company
 - f. Zurn Industries, LLC
 - 2. Standard: MSS SP-67, Type I.
 - 3. CWP Rating: 175 psig.
 - 4. Body Material: Coated, ductile iron.
 - 5. Ends: Grooved.

6. Stem: Two-piece stainless steel.
7. Disc: Coated, ductile iron.
8. Seat: EPDM.

2.5 CHECK VALVES

- A. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 125:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Crane Fluid Systems; Crane Co.
 - c. Jenkins Valves; a Crane Co. brand
 - d. Milwaukee Valve Company
 - e. NIBCO INC.
 - f. Red-White Valve Corp.
 2. Standard: MSS SP-80, Type 3.
 3. CWP Rating: 200 psig.
 4. Body Design: Horizontal flow.
 5. Body Material: ASTM B62, bronze.
 6. Ends: Threaded.
 7. Disc: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.

- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
- H. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves, Swing Type: In horizontal position with hinge pin level.
- I. Valve Tags: Comply with requirements for valve tags and schedules in Section 23 0553 "Identification for HVAC Piping and Equipment."
- J. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 4. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
 - 5. For Grooved-End Copper Tubing, except Steam and Steam Condensate Piping: Valve ends may be grooved.
 - 6. For Grooved-End Steel Piping, except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Smaller:
1. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; threaded or soldered ends.

3.6 HEATING-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Smaller:
1. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; threaded or soldered ends.

3.7 CHILLED-WATER BUTTERFLY VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; 150 CWP, EPDM seat.
 2. Butterfly valves, grooved end - ductile iron, 175 CWP.

3.8 CHILLED-WATER CHECK VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
- C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
1. Check valves, swing type, grooved ends - iron, 300 CWP.

END OF SECTION 23 0523

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe hangers and supports - carbon steel.
 - 2. Pipe/tube hangers and supports - copper.
 - 3. Pipe hangers - metal, trapeze type.
 - 4. Strut support system - metal, rod type.
 - 5. Strut support system - metal, cable type.
 - 6. Strut support system - rooftop-mounted pipe stand, compact.
 - 7. Strut support system - rooftop-mounted pipe stand, single base, single pipe, low profile.
 - 8. Strut support system - rooftop-mounted pipe stand, single base, single pipe, high profile.
 - 9. Strut support system - rooftop-mounted pipe stand, curb-mounted type.
 - 10. Strut support system - rooftop-mounted pipe stand, multiple pipe, high profile.
 - 11. Thermal hanger shield inserts.
 - 12. Fastener system - powder-actuated fasteners.
 - 13. Fastener system - mechanical expansion anchors.
 - 14. Equipment supports.
 - 15. Equipment stands - outdoor type.
- B. Related Requirements:
 - 1. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Section 23 0500 "Common Work Results for HVAC" for pipe guides and anchors.
 - 3. Section 23 0548.13 "Vibration Controls for HVAC" for vibration isolation devices.
 - 4. Section 23 3113 "Metal Ducts".

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze pipe hangers.
 - 2. Metal strut support systems.
 - 3. Rooftop-mounted strut support systems.
 - 4. Pipe stands.
 - 5. Equipment supports.
- C. Delegated Design Submittals: For trapeze hangers and strut support systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication/assembly and design calculations for trapeze hangers.

2. Detail fabrication/assembly and design calculations for each type of strut support system, by the manufacturer's technical representative.

- D. Sustainable Design Submittals:

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design trapeze hangers, strut support systems, and equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment are to withstand the effects of gravity loads and stresses within limits and under conditions indicated in accordance with ASCE/SEI 7.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 PIPE HANGERS AND SUPPORTS - METAL

- A. Pipe Hangers and Supports - Carbon Steel:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. FNW; Ferguson Enterprises, Inc.
 2. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 3. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 4. Nonmetallic Coatings: Plastic coated, or epoxy powder coated.
 5. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 6. Hanger Rods: Continuous-thread rod, nuts, and washers made of carbon steel.

- B. Pipe/Tube Hangers and Supports - Copper:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. FNW; Ferguson Enterprises, Inc.
 2. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 PIPE HANGERS - METAL, TRAPEZE TYPE

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 STRUT SUPPORT SYSTEMS - METAL

- A. Strut Support System - Metal, Rod Type:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Atkore Unistrut
 - c. Empire Industries, Inc.
 - d. Flex-Strut Inc.
 - e. G-Strut
 - f. Haydon Corporation
 - g. PHD Manufacturing, Inc
 2. Description: Factory-fabricated pipe-support assembly made of steel channels, vertical metal support rods, accessories, fittings, and other components for supporting multiple parallel pipes.
 3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 4. Struts: Continuous slotted carbon-steel channel with inturned lips or angle.
 5. Strut Width: Selected for applicable load criteria.
 6. Strut Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
 8. Metallic Coating: Plain.
 9. Paint Coating: Green epoxy, acrylic, or urethane.
 10. Plastic Coating: PVC.

2.5 STRUT SUPPORT SYSTEMS - ROOFTOP MOUNTED

- A. Strut Support System - Rooftop-Mounted Pipe Stand, Compact:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. G-Strut
 - b. MIRO Industries Inc.
 2. Description:
 - a. Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
 3. Configuration: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 4. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 5. Hardware: Galvanized steel or polycarbonate.
 6. Accessories: Protection pads.
- B. Strut Support System - Rooftop-Mounted Pipe Stand, Single Base, Single Pipe, Low Profile:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. G-Strut
 - b. MIRO Industries Inc.
 2. Description:
 - a. Shop-fabricated assembly made of manufactured corrosion-resistant components to support rooftop-mounted piping.
 3. Configuration: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 4. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 5. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch rods.
 6. Horizontal Member: Adjustable-height, galvanized-steel pipe support channels.
 7. Pipe Supports: Roller or Clevis hanger.
 8. Hardware: Galvanized steel.
 9. Accessories: Protection pads.
 10. Height: 12 inches above roof.
- C. Strut Support System - Rooftop-Mounted Pipe Stand, Curb-Mounted Type: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 THERMAL HANGER SHIELD INSERTS

- A. Thermal Hanger Shield Inserts:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA
 - b. Buckaroos, Inc.

- c. KB Enterprise
- d. Pipe Shields Inc.
- e. Piping Technology & Products, Inc
- f. Rilco Manufacturing Co., Inc
2. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100 psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125 psi minimum compressive strength and vapor barrier.
3. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100 psi minimum compressive strength.
4. For Trapeze or Clamped Systems: Insert and shield are to cover entire circumference of pipe.
5. For Clevis or Band Hangers: Insert and shield are to cover bottom 180 degrees of pipe.
6. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

- A. Fastener System - Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities required for supported loads and building materials where used.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC
- B. Fastener System - Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities required for supported loads and building materials where used.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - e. MKT Fastening, LLC
 2. Indoor Applications: Zinc-plated or stainless steel.
 3. Outdoor Applications: Stainless steel.

2.8 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.9 EQUIPMENT STANDS, OUTDOOR TYPE

- A. Equipment Stands, Outdoor Type:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. DiversiTech Corp.
 - b. MIRO Industries Inc.
 - 2. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground- or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on site.
 - 3. Foot Material: Rubber or polypropylene.
 - 4. Rails Material: Hot dip galvanized carbon steel.

2.10 MATERIALS

- A. Aluminum: ASTM B221.
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000 psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static loads within specified loading limits. Minimum static design load used for strength determination is to include weight of supported components plus 200 lb.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- F. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 - a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches long and 0.048 inch thick.
 - b. NPS 4 (DN 100): 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches long and 0.06 inch thick.
- G. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

- H. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate in accordance with ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. Strut System Installation: Metal, rod type. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems. Install in accordance with manufacturer's written installation instructions.
- J. Thermal Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- K. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick after concrete is placed and cured. Use installers that are trained and certified by power tool manufacturer.
 - 2. Install mechanical-expansion anchors after concrete is placed and completely cured.
 - 3. Install fasteners in accordance with manufacturer's written instructions.
 - 4. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
- L. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.
- M. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- N. Equipment Support Installation:
 - 1. Fabricate from welded-structural-steel shapes.
 - 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 - 3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.
 - 4. Provide lateral bracing, to prevent swaying.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded.

- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal Hanger Shield Inserts: For supporting insulated pipe.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 0529

SECTION 23 0548.13 - VIBRATION CONTROLS FOR HVAC**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Elastomeric isolation pads.
 2. Elastomeric isolation mounts.
 3. Restrained elastomeric isolation mounts.
 4. Open-spring isolators.
 5. Housed-spring isolators.
 6. Restrained-spring isolators.
 7. Housed-restrained-spring isolators.
 8. Pipe-riser resilient support.
 9. Resilient pipe guides.
 10. Elastomeric hangers.
 11. Spring hangers.
 12. Snubbers.
 13. Restraints - rigid type.
 14. Restraints - cable type.
 15. Restraint accessories.
 16. Post-installed concrete anchors.
 17. Concrete inserts.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Annotate to indicate application of each product submitted and compliance with requirements.
 2. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Consequential Damage: Provide additional restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in ASCE/SEI 7-16 so that failure of a non-essential or essential HVAC component will not cause the failure of any other essential architectural, mechanical, or electrical building component.
- B. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- C. Component Supports:
 - 1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 - 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
 - 3. Size: Factory or field cut to match requirements of supported equipment.
 - 4. Minimum deflection as indicated on Drawings.
 - 5. Pad Material: Oil- and water-resistant rubber.
 - 6. Infused nonwoven cotton or synthetic fibers.
 - 7. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

- A. Elastomeric Isolation Mounts:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 - 2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

- b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated on Drawings.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

- A. Restrained Elastomeric Isolation Mounts:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
 3. Minimum deflection as indicated on Drawings.

2.5 OPEN-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
 7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
 8. Minimum deflection as indicated on Drawings.

2.6 HOUSED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Minimum deflection as indicated on Drawings.
 7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Top housing with threaded mounting holes and internal leveling device.

2.7 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
 3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 8. Minimum deflection as indicated on Drawings.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 7. Minimum deflection as indicated on Drawings.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- Thick Neoprene:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 3. Maximum Load Per Support: 500 psi on isolation material providing equal isolation in all directions.
 4. Minimum deflection as indicated on Drawings.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- Thick Neoprene:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.

- c. Vibration Eliminator Co., Inc
2. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
 4. Minimum deflection as indicated on Drawings.

2.12 SPRING HANGERS

- A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries, Inc.
 - c. Vibration Eliminator Co., Inc
 2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Minimum deflection as indicated on Drawings.
 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 10. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Kinetics Noise Control, Inc
 - 2. Mason Industries, Inc.
 - 3. Vibration Management Corp.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 - 1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
 - 2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
 - 3. Anchors in Masonry: Design in accordance with TMS 402.
 - 4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 - 5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.14 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Atkore Unistrut
 - 2. Cooper B-line; brand of Eaton, Electrical Sector
 - 3. Hilti, Inc.
- B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper B-line; brand of Eaton, Electrical Sector
 - 2. Gripple Inc.
 - 3. Loos & Co. Inc.
- B. Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

- C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19-16. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.16 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Atkore Unistrut
 - 2. Cooper B-line; brand of Eaton, Electrical Sector
 - 3. Hilti, Inc.
 - 4. Loos & Co. Inc.
 - 5. Mason Industries, Inc.
- B. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.17 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Atkore Unistrut
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. Hilti, Inc.
 - d. Mason Industries, Inc.
 - e. Powers Fasteners
 - 2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.

- B. Adhesive Anchor Bolts:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Atkore Unistrut
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. Hilti, Inc.
 - d. Mason Industries, Inc.
 - e. Powers Fasteners
 - 2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16, Ch. 13.
 - 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

2.18 CONCRETE INSERTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Atkore Unistrut
 - 2. Cooper B-line; brand of Eaton, Electrical Sector
 - 3. Hilti, Inc.
 - 4. Mason Industries, Inc.
 - 5. Powers Fasteners
- B. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.
- C. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind-load forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROL DEVICES

- A. Provide vibration control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 3000 "Cast-in-Place Concrete."
- C. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
- D. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- F. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- G. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

H. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL MOTION

- A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties" for piping flexible connections.

3.5 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.

7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

END OF SECTION 23 0548.13

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Valve tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Valve Schedules: Provide for each piping system. Include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Brady Corporation
 - 2. emedco
 - 3. Kolbi Pipe Marker Co.
 - 4. Marking Services Inc.
 - 5. Seton Identification Products; a Brady Corporation company

2.2 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
 - 2. Letter and Background Color: As indicated for specific application under Part 3.
 - 3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
 - 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 6. Fasteners: Stainless steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation
 - 3. Carlton Industries, LP
 - 4. Champion America
 - 5. Craftmark Pipe Markers
 - 6. emedco
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Pipemarker.com; Brimar Industries, Inc.
 - 11. Seton Identification Products; a Brady Corporation company
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation
 - 3. Carlton Industries, LP
 - 4. Champion America
 - 5. Craftmark Pipe Markers
 - 6. emedco
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Pipemarker.com; Brimar Industries, Inc.

11. Seton Identification Products; a Brady Corporation company
- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brasslink chain or beaded chain or S-hook.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 1. Include valve-tag schedule in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

- A. Permanently fasten labels on each item of mechanical equipment.
- B. Sign and Label Colors:
 1. White letters on black background.
- C. Locate equipment labels where accessible and visible.
- D. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF PIPE LABELS

- A. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- B. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 25 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping, ductwork, and equipment.
- C. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- D. Flow-Direction Arrows: Use arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Pipe-Label Color Schedule:
 - 1. Chilled-Water Piping: White letters on an ANSI Z535.1 safety-green background.
 - 2. Heating Water Piping: Black letters on an ANSI Z535.1 safety-yellow background.

3.5 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.
 - 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - 2. Valve-Tag Colors:
 - a. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. The Work of this Section Includes:
 - 1. TAB of Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - c. Multizone systems.
 - 2. TAB of Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
 - 3. TAB of equipment.
 - 4. TAB of existing HVAC systems and equipment.
 - 5. Duct-leakage tests verification.
 - 6. Pipe-leakage tests verification.
 - 7. HVAC-control system verification.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. FFT: Fast Fourier transform.
- C. INCE: Institute of Noise Control Engineering
- D. NC: Noise criteria.
- E. NEBB: National Environmental Balancing Bureau.
- F. RC: Room criteria.
- G. TAB: Testing, adjusting, and balancing.
- H. TABB: Testing, Adjusting, and Balancing Bureau.
- I. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- J. TDH: Total dynamic head.

1.3 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan, to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:

- a. The Contract Documents examination report.
- b. The TAB plan.
- c. Requirements for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. TAB Report: Documentation indicating that the Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, provide a summary report of the examination review required in "Examination" Article, if issues are discovered that may preclude the proper testing and balancing of the systems. Submit a summary report of the examination review required in "Examination" Article.
- C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article, to be used and filled out by systems installers verifying that systems are ready for TAB.
- E. Certified TAB Reports: Within 14 days of completion of testing and balancing work.
 - 1. Submit one copy of the final TAB report to the design professional of record's firm. Provide five additional copies to Contractor.
- F. Sample report forms.
- G. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration and calibration interval.

1.6 QUALITY ASSURANCE

- A. TAB Specialist Firm's Qualifications: Certified by NEBB or TABB.
 - 1. TAB Certified Professional: Employee of the TAB specialist firm and certified by NEBB or TABB.

- 2. TAB Technician: Employee of the TAB specialist firm and certified by NEBB or TABB.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE 111 compliance for testing and balancing of HVAC systems.
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.3.3 - "System Balancing."
- E. Code and Authorities Having Jurisdiction Compliance: Furnish TAB services that comply with governing codes and requirements of authorities having jurisdiction.

1.7 FIELD CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TAB SPECIALIST FIRMS

- A. Subject to compliance with requirements, engage one of the following:
 - 1. Air Economics, Inc.
 - 2. Control Solutions, Inc.
 - 3. Great Lakes Balancing
 - 4. Pro-Mec Engineering Services, Inc.

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in system designs that may preclude proper TAB of systems and equipment. Submit Contract Documents Examination Report summary of findings.
- B. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Note the locations of devices that are not accessible for TAB.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- E. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean and permanent filters are installed, and equipment with functioning controls is ready for operation.

- F. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning as indicated on Drawings or in the Specifications.
- G. Verify, with installation Contractor, that startup strainer screens have been replaced with permanent screens and that all strainers have been cleaned.
- H. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- I. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- J. Examine air vents to verify that air has been removed from all hydronic systems.
- K. Observe demonstration of operating safety interlocks and controls on HVAC equipment.
- L. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Prepare system-readiness checklists of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Windows and doors are installed and are in normal operating positions.
 - i. Note location of balancing devices that are inaccessible.
 - 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been completed in accordance with applicable code and authorities having jurisdiction.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Verify that pressure at highest point in the system is a minimum of 4 psig.

- f. Strainers are pulled and cleaned.
- g. Control valves are functioning in accordance with the controls sequence of operation.
- h. Shutoff and balance valves have been verified to be 100 percent open.
- i. Pumps are started and proper rotation is verified.
- j. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- k. Variable-frequency controllers' startup is complete, and safeties are verified.
- l. Note location of balancing devices that are inaccessible.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in ASHRAE 111 and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. Installing Contractor to Perform the Following:
 - a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - b. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 3300 "Air Duct Accessories."
 - c. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
 - d. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 23 0713 "Duct Insulation," and Section 23 0719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP units).
- E. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Pumps.
 - 3. Fans and ventilators.
 - 4. Terminal units.
 - 5. Boilers.
 - 6. Unit heaters.
 - 7. Water chillers.

8. Air-handling units.
9. Coils.
10. Convectors.
11. Finned-tube radiation heaters.

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain approved submittals and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare single-line schematic diagram of systems or color-coded HVAC drawings for the purpose of identifying HVAC components, including each air terminal unit and each air diffuser, register, and grille.
- C. For variable-air-volume systems, develop a plan to simulate diversity and include in TAB plan.
- D. Determine suitable locations in main and branch ducts for accurate duct-airflow measurements.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
- F. Verify that motor controllers are equipped with properly sized thermal protection.

3.7 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure differential across each component that makes up the air-handling system.
 - d. Apply artificial loading of filters to simulate a dirty filter pressure drop condition at the time static pressures are measured.
 3. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all volume dampers have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets' and outlets' airflow. Apply correction factors as applicable for each size and style of air device.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
 1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design range. Readjust to within design tolerance if necessary.
 2. Re-measure and confirm that total airflow is within design.
 3. Re-measure all final fan operating data, speed, volts, amps, and static profile.
 4. Traverse the supply airflow in full airside economizer mode. Observe the mixed air plenum pressure as compared to normal operation: return air dampers open and minimum outside air varying to 100 percent outside air dampers fully open and return air dampers fully closed. Mixed air pressure is to remain constant plus/minus 20 percent or, otherwise, damper/fan adjustments will be required.
 5. Mark all final settings.
 6. Measure and record all operating data.
 7. Record final fan-performance data.

3.8 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Adjust the variable-air-volume systems as follows:
 1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
 2. Verify that the system is under static pressure control.
 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.

- b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. Set the air terminal units to maximum airflow. Record the following for each air terminal unit:
 - a. Design maximum airflow.
 - b. Tested and balanced maximum airflow.
 - c. BAS system maximum airflow.
 - d. BAS damper position.
 - e. Adjust the air-handling unit fan airflow until one air terminal unit damper position is 85 percent open.
 - f. Record the duct static pressure sensor and set the fan static pressure controller to the recorded static pressure sensor.
 - g. Record the fan operating Hz.
 - h. If the system has filters that will exceed 0.5 inch wg pressure differential when dirty, simulate the dirty filter pressure drop and repeat all the above recorded readings ("a" through "g"), noting dirty filter condition.
 - i. With N+1, isolate one fan and repeat all the above recorded readings ("a" through "g"), noting N+1 condition.
 - j. Each condition must have all air-handling- unit data recorded, including static pressure profiles at outdoor air, return air, relief air, total supply air, supply air fan suction and discharge, return air fan suction and discharge, and relief air fan suction and discharge.
6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet.
 - b. Measure static pressure directly at the fan inlet.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point, to maintain the optimum system static pressure. Record set point and give to controls Contractor.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.

- b. Re-measure and confirm that total airflow is within design.
- c. Re-measure final fan operating data, speed, volts, amps, and static profile.
- d. Mark final settings.
- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans.

3.9 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Cross-check the summation of required coil and equipment flow rates with pump design flow rate.
- B. Prepare single-line schematic diagram of systems for the purpose of identifying HVAC components.
- C. Prepare schematic diagrams of systems' record Drawings piping layouts.
- D. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 - 1. Check expansion tank for proper setting.
 - 2. Check highest vent for adequate pressure.
 - 3. Check flow-control valves for proper position.
 - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 - 5. Verify that motor controllers are equipped with properly sized thermal protection.
 - 6. Check that air has been purged from the system.
- E. Measure and record upstream and downstream pressure of each piece of equipment.
- F. Measure and record upstream and downstream pressure of pressure-reducing valves.
- G. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
 - 1. Check settings and operation of each safety valve. Record settings.

3.10 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design flow.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.

- d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify if any future load requirements and close throttling valve, noting the position.
 3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.
 1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
 6. Use coil pressure drop to determine flow if no flow meter measurement exists.
 7. Use temperatures and flows to calculate actual capacity on each coil and heat exchanger.
- D. For systems with pressure-independent valves at terminals:
 1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
 1. Measure and balance coils by either coil pressure drop or by capacity method calculation.
 2. Use coil pressure drop to determine flow.
 3. Perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
 1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- G. Verify that memory stops have been set. Add and mark all balanced valve positions for valves that do not have memory stops.

3.11 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
 - 1. Verify that the pressure-differential sensor(s) is located as indicated.
 - 2. Determine whether there is diversity in the system.
- C. For systems with no flow diversity:
 - 1. Adjust pumps to deliver total design flow with variable frequency drive(s) set to 60 Hz.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 - 2. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
 - 3. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow by using manually balancing valve.
 - c. Re-measure each main and branch after all have been adjusted.
 - 4. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.

- e. Perform temperature tests after flows have been balanced.
 5. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 6. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 7. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
 8. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, verify the pressure at the controller sensor and set the controller to the measured pressure at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions. Reverify the pressure at the controller.
 9. Mark final settings and verify that all memory stops have been set.
 10. Verify final system conditions as follows:
 - a. Re-measure and confirm that total flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, static pressure profile, and variable-frequency drive Hz.
 - c. Mark final settings.
- D. For systems with flow diversity:
 1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves located closest to the pump(s).
 3. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.

- c. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
4. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
5. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
6. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
7. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
8. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
9. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
10. Prior to verifying final system conditions, determine system pressure-differential set point(s).
11. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
12. Mark final settings and verify that memory stops have been set.
13. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.

3.12 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.
- C. Adjust pumps to deliver total design flow.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 - d. Verify pump impeller size by measuring TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 - e. With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling. Before pump impellers are trimmed, verify future load requirements and close throttling valve, noting the position.
 - 3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition. While operating pump(s) at maximum flow conditions, verify pump(s) are operating below nameplate and are non-overloading through full range of operation.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - 1. Measure flow in main and branch pipes.
 - 2. Adjust main and branch balance valves for design flow.
 - 3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - 1. Measure flow at terminals.
 - 2. Adjust each terminal to design flow.
 - 3. Re-measure each terminal after it is adjusted.
 - 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - 5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
 - 1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after flows have been balanced.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
 1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
 1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 3. Mark final settings.
- I. Verify that memory stops have been set.

3.13 PROCEDURES FOR MOTORS

- A. Motors: 1/2 hp and larger; test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation. Verify and report Hz at maximum and minimum flows.

3.14 PROCEDURES FOR WATER CHILLERS

- A. Air-Cooled Chillers: Balance water flow through each evaporator to within specified tolerances of indicated flow, with all pumps operating. With only one chiller operating in a multiple-chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 2. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer or via chiller control panel readout.
 3. Power factor if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
 4. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts or via chiller control panel readout.
 5. Capacity: Calculate in tons of cooling via chiller control panel readout.
 6. Verify condenser-fan rotation and record fan and motor data, including number of fans and entering- and leaving-air temperatures.

3.15 PROCEDURES FOR BOILERS

- A. Hydronic Boilers:
 - 1. Measure and record entering- and leaving-water temperatures.
 - 2. Measure and record water flow.
 - 3. Measure and record pressure drop.
 - 4. Record relief valve(s) pressure setting.
 - 5. Fan, motor, and motor controller operating data.
- B. Gas-Fired Boilers:
 - 1. Test and document proper operation of emergency gas shut-down switch.

3.16 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each hydronic coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
 - 8. Use coil pressure drop to determine flow if no flow meter measurement exists.
 - 9. Use temperatures and flows to calculate actual capacity on each coil and heat-transfer coils.

3.17 PIPE-LEAKAGE TESTS

- A. Witness the pipe pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.18 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Work to ensure the system is operating within the design limitations and gain a mutual understanding of intended controls performance.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.

9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.19 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
 2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
 3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 4. Check the condition of filters.
 5. Check the condition of coils.
 6. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. TAB after Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:
 1. New filters are installed.
 2. Coils are clean and fins combed.
 3. Drain pans are clean.
 4. Fans are clean.
 5. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 1. Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan speed and the face velocity of filters and coils.
 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 3. Balance each air outlet.

3.20 TOLERANCES

- A. Set HVAC system's airflow rates and water-flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, flow rate is within 10 cfm.
 2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, flow rate is within 10 cfm.

3. Heating-Water Flow Rate: Plus or minus 10 percent. If design value is less than 10 gpm, flow rate is within 10 percent.
 4. Chilled-Water Flow Rate: Plus or minus 5 percent. If design value is less than 10 gpm, flow rate is within 10 percent.
- B. Maintaining pressure relationships as designed is to have priority over the tolerances specified above. If the above tolerances change the relative positive or negative airflow from/into the space, tolerances are to be adjusted so as to keep the relative positive cfm or negative cfm from/into the space a constant cfm differential.

3.21 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for system-balancing devices. Recommend changes and additions to system-balancing devices, to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance-measuring and -balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.22 FINAL TESTING AND BALANCING REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB specialist firm and technician.
 3. Project name.
 4. Project location.
 5. Project Architect's name, firm, and address.
 6. Project engineer's name, firm, and address.
 7. Project Contractor's name, firm, and address.
 8. Report date.

9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents, including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fan performance forms, including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. Variable-frequency controller settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.

- j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 - 2. Motor Data:
 - a. Motor make and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan speed.
 - d. Inlet and discharge static pressure in inches wg.
 - e. For each filter bank, filter static-pressure differential in inches wg.
 - f. Cooling-coil static-pressure differential in inches wg.
 - g. Heating-coil static-pressure differential in inches wg.
 - h. List for each internal component with pressure-drop, static-pressure differential in inches wg.
 - i. Outdoor airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
- F. Apparatus-Coil Test Reports:
 - 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water-flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.

- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
 2. Motor Data:
 - a. Motor make and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan speed.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
 - a. System fan and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.

- g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump speed.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.

- c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- L. Instrument Calibration Reports:
- 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration and interval.

3.23 VERIFICATION OF TAB REPORT

- A. The TAB specialist firm's test and balance technician is to conduct the final verification in the presence of the Construction Manager and Commissioning Authority.
- B. Commissioning Authority to randomly select measurements, documented in the final report, to be rechecked. Rechecking is to be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements are to be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 20 percent of the total measurements checked during the final inspection, the TAB are to be considered incomplete and are to be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
 - 1. TAB specialists are to recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection. All changes are to be tracked to show changes made to previous report.
 - 2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

3.24 REVERIFICATION

- A. TAB specialist firm technicians are to recheck all measurements and make adjustments as required to complete the balancing. Revise the final report and balancing device settings to include all changes; resubmit final report and request a second verification.
- B. If the second verification also fails, Owner may contact TABB Quality Assurance Program, Customer Complaint Procedures.

3.25 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 0593

SECTION 23 0713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Outdoor, concealed supply and return.
 - 6. Outdoor, exposed supply and return.
- B. Related Requirements:
 - 1. Section 23 3113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral Wool Blanket: Basalt volcanic rock-derived fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C553.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Owens Corning
 - c. ROCKWOOL

- G. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 250 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in the "Factory-Applied Jackets" Article.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed; SAINT-GOBAIN
 - b. Johns Manville; a Berkshire Hathaway company
 - c. Knauf Insulation
 - d. Manson Insulation Inc.
 - e. Owens Corning

2.3 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Eagle Bridges - Marathon Industries
 - c. Foster Brand; H. B. Fuller
 - d. Mon-Eco Industries, Inc.
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Eagle Bridges - Marathon Industries
 - c. Foster Brand; H. B. Fuller
 - d. Mon-Eco Industries, Inc.
 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.4 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
1. Materials are compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 4. Color: Aluminum.

5. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.5 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
 6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

2.8 INSULATION PINS AND HANGERS

- A. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 1. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 2. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

3. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- B. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 1. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 2. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 3. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- C. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 1. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 2. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 3. Adhesive-backed base with a peel-off protective cover.

2.9 STAPLES:

- A. Outward-clinching type, nominal 3/4-inch- wide, stainless steel or Monel.

2.10 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Comply with requirements in Section 07 8413 "Penetration Firestopping."

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins in compliance with manufacturer's written installation instructions.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Comply with manufacturer's written installation instructions.
- B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 07 8413 "Penetration Firestopping."

3.8 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below.
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

- C. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
- B. Items Not Insulated:
 - 1. Fibrous-glass ducts.
 - 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 - 3. Factory-insulated flexible ducts.
 - 4. Factory-insulated plenums and casings.
 - 5. Flexible connectors.
 - 6. Vibration-control devices.
 - 7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
- B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber blanket, 2 inches thick and 2-lb/cu. ft. nominal density.
- D. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber blanket, 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
- E. Exposed, Round Supply-Air Duct: Mineral-fiber blanket, 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.

- F. Exposed, Rectangular Supply-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
- G. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- H. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
- I. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber board, 1-1/2 inches thick and 2-lb/cu. ft. nominal density, or Mineral-fiber blanket, 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
- D. Ducts and Plenums, Exposed in Finished Spaces:
 - 1. PVC: 30 mils thick.

END OF SECTION 23 0713

SECTION 23 0719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulation for HVAC piping systems.
- B. Related Requirements:
 - 1. Section 23 0713 "Duct Insulation" for duct insulation.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size.

1.5 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authority having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- D. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Knauf Insulation
 - c. Manson Insulation Inc.
 - d. Owens Corning
 - 2. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ-SSL.
 - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- E. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F in accordance with ASTM C447. Comply with ASTM C547.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Owens Corning
 - c. ROCKWOOL
 - 2. Preformed Pipe Insulation: Type II, Grade A with factory-applied ASJ-SSL.
 - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.

- F. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F, in accordance with ASTM C411. Comply with ASTM C1393.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed; SAINT-GOBAIN
 - b. Johns Manville; a Berkshire Hathaway company
 - c. Knauf Insulation
 - d. Manson Insulation Inc.
 - e. Owens Corning
 2. Semirigid board material with factory-applied ASJ jacket.
 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F, in accordance with ASTM C411. Comply with ASTM C1393.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Owens Corning
 - c. ROCKWOOL
 2. Semirigid board material with factory-applied ASJ jacket.
 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.
- C. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - d. Vimasco Corporation
 - 2. Adhesive: As recommended by calcium silicate manufacturer and with a VOC content of 50 g/L or less.
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - 2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- D. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand; H. B. Fuller Construction Products
 - b. Foster Brand; H. B. Fuller
 - c. Mon-Eco Industries, Inc.
 - 2. Adhesives shall have a VOC content of 50 g/L or less.
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- E. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation
 - d. Sekisui Voltek, LLC
 - e. Speedline Corporation
 - f. The Dow Chemical Company
 - 2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.5 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
 - 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
 - 2. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to plus 180 deg F.
- C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.
 - 3. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: 0 to plus 180 deg F.
 - 3. Color: White.

2.6 LAGGING ADHESIVES

- A. Lagging Adhesives: Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.
 - 1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 - 4. Service Temperature Range: 0 to plus 180 deg F.
 - 5. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.

2.8 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 - 4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 - 5. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Airex Manufacturing Inc.
 - b. Johns Manville; a Berkshire Hathaway company
 - c. P.I.C. Plastics, Inc.
 - d. Proto Corporation

- e. Speedline Corporation
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: White.
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- C. Metal Jacket:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. RPR Products, Inc.
 - 2. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- D. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. 3M
 - b. Foster Brand; H. B. Fuller
 - c. Ideal Tape Co., Inc., an American Biltrite Company
 - 2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 - 3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 - 4. Aluminum Finish: Embossed.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

2.11 SECUREMENTS

- A. Bands:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. RPR Products, Inc.
 - 2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
 - 3. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
 - 4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Staples: Outward-clinching insulation staples, nominal 3/4 inch wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using prefabricated fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with prefabricated fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using prefabricated fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.6 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
 4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install prefabricated pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.

4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FIELD-APPLIED JACKETS

- A. Where PVC jackets are indicated and for horizontal applications, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective if they do not pass tests and inspections.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Chilled Water and Brine, Above 40 Deg F:
 - 1. NPS 12 and Smaller: Insulation is one of the following:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.
 - b. Mineral Wool, Preformed Pipe Insulation, Type II: 1-1/2 inches thick.
- B. Heating-Hot-Water Supply and Return, 200 Deg F and Below:
 - 1. NPS 12 and Smaller: Insulation is one of the following:
 - a. Glass-Fiber, Preformed Pipe, Type I: 2 inches thick.
 - b. Mineral Wool, Preformed Pipe, Type II: 2 inches thick.

3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Chilled Water and Brine:
 - 1. All Pipe Sizes: Insulation is one of the following:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 3 inches thick.
 - b. Mineral Wool, Preformed Pipe Insulation, Type II: 3 inches thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Exposed (8 feet or less above finished floor):
 - 1. PVC: 30 mils thick.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Exposed:
 - 1. Aluminum, Stucco Embossed: 0.020 inch thick.

END OF SECTION 23 0719

SECTION 23 0800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:
 - 1. Heat generation systems.
 - 2. Cooling generation systems.
 - 3. Central-station air-handling systems.
 - 4. Air and hydronic distribution systems.
 - 5. Heating and cooling terminal and unitary equipment.
 - 6. HVAC controls.
 - 7. TAB verification.
- B. Related Requirements:
 - 1. Section 01 9113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 01 9113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 01 9113 "General Commissioning Requirements."
- D. IgCC: International Green Construction Code.
- E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.
- F. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

- A. Construction Checklists:
 - 1. Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to BAS and HVAC to be part of the Cx process and in accordance with requirements in Section 01 9113 "General Commissioning Requirements and ASHRAE 202."

1.4 QUALITY ASSURANCE

- A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
 - 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
 - 2. Minimum three years' experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.
- C. Testing Equipment and Instrumentation Quality and Calibration:
 - 1. Capable of testing and measuring performance within the specified acceptance criteria.
 - 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 - 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform Cx process in accordance with Section 01 9113 "General Commissioning Requirements" for BAS and HVAC and in accordance with the following:
 - 1. ASHRAE 202.

3.2 CONSTRUCTION CHECKLISTS

- A. Prepare preliminary detailed construction checklists for each BAS and HVAC system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in ASHRAE 202.
 - 1. Submit preliminary construction checklists to CxA and Designer for review.
 - 2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."

3. Use only construction checklists, marked "Approved for Use, (date)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed and provide pertinent details and other information.
- B. Additional systems required to be commissioned:
 1. Heat generation systems, including the following:
 - a. Boilers.
 - b. Auxiliary equipment.
 2. Cooling generation systems, including the following:
 - a. Water chillers.
 3. Air-handling systems, including the following:
 - a. Supply, return, and exhaust air fans, motors, and drives.
 - b. Automatic and gravity dampers.
 - c. Heating and cooling devices.
 - d. Air filters.
 - e. Interlock between air-handling system and fire/smoke alarm system.
 4. Hydronic distribution systems, including the following:
 - a. Hydronic piping systems and all accessories.
 - b. Pumps and all accessories.
 - c. Sleeves and sleeve seals.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports
 5. Heating and cooling terminal and unitary equipment, including the following:
 - a. Finned-tube radiation.
 - b. Unitary heating equipment.
 6. Controls and instrumentation, including the following:
 - a. Controllers and sensors.
 - b. Automatic control valves, dampers, and actuators.
 - c. Control interface with fans, pumps, dampers, and other equipment and systems.
 7. TAB Verification:
 - a. Airflow.
 - b. Water flow.
 8. Documentation:
 - a. Mechanical systems manuals.
 - b. Documentation of required commissioning.

3.3 Cx TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.

- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and all systems are set to and maintaining set points as required by the design documents.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 Cx TESTS COMMON TO HVAC SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

3.6 TAB VERIFICATION

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
- C. Scope: HVAC air systems and hydronic piping systems.
- D. Purpose: Differential flow relationships intended to maintain air and water pressurization differentials between the various areas of Project.
- E. Conditions of the Test:
 - 1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
 - 2. Systems operating in full heating mode with minimum outside-air volume.
 - 3. Systems operating in full cooling mode with minimum outside-air volume.
 - 4. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.
- F. Acceptance Criteria:
 - 1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
 - 2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
 - 3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.7 HEATING CONTROL SYSTEM Cx TESTS

- A. Heating-Water Supply Temperature Control:
 - 1. Prerequisites: Installation verification of the following:
 - a. Startup of boiler.
 - b. Startup of heating-water pump(s).
 - c. TAB of heating-water flow and pressure.
 - d. Input Device: Heating-water supply temperature; thermistor temperature sensor.

- e. Output Device: Control valve or boiler modulation/staging.
 - f. Display the following at the operator's workstation:
 - 1) Heating-water supply temperature.
 - 2) Heating-water supply temperature set point.
 - 3) Control-valve position or boiler output.
 2. Scope: Heating-water system.
 3. Purpose: Control of heating-water supply temperature at input device.
 4. Conditions of the Test:
 - a. Minimum heating-water flow.
 - b. Midrange Heating-Water Flow: 50 to 60 percent of maximum.
 - c. Maximum heating-water flow.
 5. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F of set point.
- B. Heating-Water Supply Temperature Reset:
 1. Scope: Heating-water system.
 2. Purpose: Control of heating-water supply temperature at heating-water supply temperature input device in response to variable outdoor-air temperature input; outdoor-air sensor.
 3. Conditions of the Test (unless noted otherwise): Outdoor-air temperature input value may be overridden for this test.
 - a. Low Temperature: Outdoor-air temperature between minus 30 and 0 deg F.
 - b. Midrange Temperature: Outdoor-air temperature between 20 and 30 deg F.
 - c. High Temperature: Outdoor-air temperature above 40 deg F.
 4. Acceptance Criteria: Heating-water supply temperature resets in straight-line relationship with outdoor-air temperature for the following reset schedule. Under all conditions, heating-water supply temperature is within 2.0 deg F of set point.
 - a. 190 deg F heating water when outdoor-air temperature is 0 deg F.
 - b. 170 deg F heating water when outdoor-air temperature is 40 deg F.
 - c. Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F of set point.
- C. Control Primary Circulating Pump(s):
 1. Prerequisites: Installation verification of the following:
 - a. Startup of heating-water pump(s).
 - b. Input Device: Outdoor-air temperature; outdoor-air sensor.
 - c. Output Device: Heating-water pump; DDC system command to starter relay.
 - d. Display the following at the operator's workstation:
 - 1) Outdoor-air temperature.
 - 2) Operating status of primary circulating pump(s).
 2. Scope: Heating-water pump(s) and associated controls.
 3. Purpose: On-off control of heating-water pump(s) in response to variable outdoor-air temperature input; outdoor-air sensor.
 4. Conditions of the Test (unless noted otherwise):
 - a. High Temperature: Outdoor-air temperature above 55 deg F.
 - b. Low Temperature: Outdoor-air temperature below 50 deg F.

5. Acceptance Criteria:
 - a. High Temperature: Pump(s) are off when outside-air temperature is above 55 deg F.
 - b. Low Temperature: Pump(s) are on when outside-air temperature is below 50 deg F.

D. Refer to Sequences of Operation on Drawings for additional requirements.

3.8 CHILLER SYSTEM Cx TESTS

- A. Start-and-Stop Chilled-Water Pump(s):
 1. Prerequisites: Installation verification of the following:
 - a. Startup of chiller(s).
 - b. Startup of chilled-water pump(s).
 - c. Input Device: Outdoor-air temperature; outdoor-air sensor.
 - d. Output Device: DDC system command to starter relay.
 - e. Display one of the following at the operator's workstation:
 - 1) Chilled-water flow indication.
 - 2) Chilled-water pump(s) on-off status.
 - 3) Chilled-water pump(s) on-off indication.
 2. Scope: Chilled-water system, including chilled-water pump(s) and associated controls.
 3. Purpose:
 - a. Chilled-water pump(s) start.
 - b. Chilled-water pump(s) shutdown.
 4. Conditions of the Test:
 - a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
 - b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device in the "disable" state.
 5. Acceptance Criteria:
 - a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
 - b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.
- B. Refer to Sequences of Operation on Drawings for additional requirements.

3.9 TERMINAL UNIT EQUIPMENT Cx TESTS

- A. VAV Terminal Air Units with Coils:
 1. Prerequisites: Installation verification of the following:
 - a. Occupancy Input Device: Occupancy sensor or BMS occupancy schedule.
 - b. Occupancy Output Device: DDC system binary output.
 - c. Room Temperature Input Device: Room thermostat.
 - d. Room Temperature Output Device: Electronic damper actuators and control-valve operators.

- e. Display the following at the operator's workstation:
 - 1) Room/area served.
 - 2) Room occupied/unoccupied.
 - 3) Room temperature indication.
 - 4) Room temperature set point.
 - 5) Room temperature set point, occupied.
 - 6) Room temperature set point, unoccupied.
 - 7) Air-damper position as percentage open.
 - 8) Control-valve position as percentage open.
2. Scope: VAV terminal air units with hydronic coils in supply-air systems, and associated controls.
3. Purpose:
 - a. Occupancy-dependent room temperature set-point reset.
 - b. Room temperature control.
4. Conditions of the Test:
 - a. Cx Test Demonstration Sampling Rate: 10 percent of each model/size unit.
 - b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point, plus or minus 1.0 deg F.
 - c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point, plus or minus 1.0 deg F.
5. Acceptance Criteria:
 - a. Temperature Control - Occupied:
 - 1) Control system status changes from "occupied" to "unoccupied" after the specified time.
 - 2) Room temperature is stable at occupied set point, plus or minus 1.0 deg F within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F during transition.
 - b. Temperature Control - Unoccupied:
 - 1) Control system status changes from "unoccupied" to "occupied" after five minutes of continuous occupancy.
 - 2) Room temperature is stable at unoccupied set point, plus or minus 1.0 deg F within 30 minutes of occupancy.

B. Refer to Sequences of Operation on Drawings for additional requirements.

3.10 AIR-HANDLING SYSTEM Cx TESTS

A. Refer to Sequences of Operation on Drawings for both Multi-zone VAV and Single-zone VAV air handling unit requirements.

END OF SECTION 23 0800

SECTION 23 0923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: The removal, installation and integration of direct digital control (DDC) system equipment and components.
 - 1. It is the Grand Rapids Public School's goal to implement a new "open/non-proprietary" Building Automation System (BAS) that will allow products from various suppliers to be integrated into a unified system to provide flexibility for expansion, maintenance, and service of the controls system.
 - a. The new BAS for this project shall monitor and control all new and existing HVAC systems and equipment as indicated in the Drawings and as noted within this specification section.
 - 2. An existing Novar DDC Control system (installed in 2006) currently monitors and controls all existing HVAC equipment and systems throughout the building.
 - a. It is the responsibility of the Controls Contractor to remove and replace the existing BAS/DDC controls system in its entirety (as indicated in Drawings, with bid alternates), including all existing devices, sensors, wiring, and accessories.
 - b. Any existing DDC controls that remain (should the bid alternates not be accepted) shall be seamlessly integrated into the new BAS.
 - 3. Refer to the Enterprise System and BAS General Description sections below.
 - 4. It is the responsibility of the Controls Contractor to provide any hardware, software, control devices, or supplementary and miscellaneous items not mentioned in this specification that are necessary for a fully functional and integrated system of temperature controls, graphic interfaces, monitoring, and management.
 - 5. Depict floor plans and each mechanical system, components, and data points on point-and-click graphics that will allow operators to perform all normal functions through Web Browser interface.
- B. Related Requirements:
 - 1. Section 23 0800 "Commissioning of HVAC" applies to this section and will require the contractor's participation in the commissioning process.
 - 2. Section 23 0923.11 "Control Valves" for valves and actuators.
 - 3. Section 23 0923.12 "Control Dampers" for dampers and actuators.
 - 4. Section 23 0923.14 "Flow Instruments" for air and liquid flow sensors.
 - 5. Section 23 0923.16 "Gas Instruments" for carbon dioxide sensors.
 - 6. Section 23 0923.19 "Moisture Instruments" for relative humidity sensors.
 - 7. Section 23 0923.23 "Pressure Instruments" for air and liquid switches and sensors.
 - 8. Section 23 0923.27 "Temperature Instruments" for air and liquid temperature sensors.
 - 9. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
 - 10. Section 23 3600 "Air Terminal Units" for required unit controllers by Controls Contractor.

11. Section 26 0553 "Identification for Electrical Systems" for identification requirements for electrical power and communications components

1.2 ENTERPRISE SYSTEM – GENERAL DESCRIPTION

- A. Grand Rapids Public Schools currently has two (2) Enterprise level software platforms that provide server level functions for a network of Building Automation System field devices. The two systems are listed below:
 1. Trane Tracer Ensemble.
 2. Tridium Niagara Supervisor.
- B. The Enterprise operator interface is a web-based, systems integration solution that provides an online, enterprise-wide view and control of all connected buildings and systems, from any device with a web browser on the network (PC, laptop, tablet, smart phone).
- C. The Enterprise system collects and displays data from other systems via BACnet IP, providing users with the information needed to make enterprise-wide decisions for optimized performance. Non-open-source protocols, such as Niagara Fox, shall not be allowed for enterprise level communication on this project.

1.3 BUILDING AUTOMATION SYSTEM (BAS) – GENERAL DESCRIPTION

- A. Provide a new BAS to interface with either one of the above-described Enterprise Systems that will integrate and control all mechanical equipment associated with this project.
 1. The BAS shall be as indicated on the drawings and described in these specifications. System must be fully integrated and coordinated with mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory as specified in those sections. The intent of the BAS is to integrate all mechanical equipment into one system for global monitoring, control, and alarming associated with the building. It is the BAS manufacturer's responsibility to provide all the design, engineering, and field coordination required to ensure all equipment sequences of operation are met as specified and the BAS operators have the capability of managing the building mechanical systems to ensure comfort while maintaining energy efficiency.
 2. The BAS shall meet open standard communication standards as defined in System Communications Section below to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BAS manufacturers in future projects.
- B. The Enterprise operator interface is a web-based, systems integration solution that provides an online, enterprise-wide view and control of all connected buildings and systems, from any device with a web browser on the network (PC, laptop, tablet, smart phone).

1.4 SYSTEM COMMUNICATION

- A. Building Automation System (BAS) Communication.
 - 1. Each workstation, building controller, and equipment/plant controller communication interface shall utilize the BACnet protocol with an Ethernet (IEEE 802.3) or RS485 (EIA-485) physical interface and an appropriate data link technology as defined in ANSI/ASHRAE Standard 135-2012 (e.g. BACnet over IP, BACnet over IPv6, BACnet SC, BACnet over MS/TP).
 - 2. All system controllers shall be BTL listed as a BACnet Building Controller (B-BC) as defined in ANSI/ASHRAE Standard 135-2012.
 - 3. All Operator Workstations (B-OWS, B-AWS) and Building Controllers (B-BC) shall support BACnet Secure Connect (BACnet SC), a secure and encrypted datalink layer specifically designed for those networks.
- B. Field Bus Communications.
 - 1. BACnet.
 - a. All equipment and plant controllers shall be BTL listed as a BACnet Application Specific Controller (B-ASC) or a BACnet Advanced Application Controller (B-AAC) as defined in ANSI/ASHRAE Standard 135-2012.
 - b. All communication shall conform to ANSI/ASHRAE Standard 135-2012.
 - c. System Controller shall function as a BACnet router to each unit controller providing a globally unique BACnet Device ID for all BACnet controllers within the system.

1.5 SYSTEM GRAPHICS

- A. Enterprise operator web interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor for each building included in this contract.
- B. Graphic Imagery: graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
- C. Animation: graphics shall be able to animate by displaying different image lies for changed object status.
- D. Alarm Indication: indicates areas or equipment in an alarm condition using color or other visual indicator.
- E. The BAS installing contractor shall schedule a preliminary graphics coordination & review meeting with Grand Rapids Public Schools prior to starting work on the project graphics. Owner feedback from this meeting shall be incorporated into the final graphics package.

1.6 SOFTWARE SERVICE TOOLS

- A. Provide Grand Rapids Public Schools with one copy of software service tool to enable controller back-up/restore, configuration, firmware update, diagnostics, and equipment status that is specifically compatible with the BACnet unit level controllers being installed as part of the project. The software shall be registered to the Owner at project completion. Manufacturer shall provide subscription to service tool for five (5) years that entitles free software updates.

1.7 CONTROL SYSTEM CHECKOUT AND TESTING

- A. Start-up Testing: all testing in this section shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner's representative is notified of the system demonstration.
- B. Verify the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimal start/stop routines. Ensure that all alarms and interlocks are set up and functional.

1.8 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
 - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data and services over a network.
 - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
- D. Binary: Two-state signal where a high signal level represents "ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

- E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: network controllers, programmable application controllers, and application-specific controllers.
- F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- G. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- H. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems to be capable of operating in a standalone mode using the last best available data.
- I. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- J. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI) and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- K. LAN: Local area network.
- L. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- M. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.
- N. Modbus TCP/IP: An open protocol for exchange of process data.
- O. MS/TP: Master-slave/token-passing, ISO/IEC/IEEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- P. MTBF: Mean time between failures.
- Q. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

- R. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- S. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- T. Router: Device connecting two or more networks at network layer.
- U. Server: Computer used to maintain system configuration, historical and programming database.
- V. TCP/IP: Transport control protocol/Internet protocol.
- W. UPS: Uninterruptible power supply.
- X. USB: Universal Serial Bus.
- Y. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- Z. VAV: Variable air volume.

1.9 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.10 ACTION SUBMITTALS

- A. Multiple Submissions:
 - 1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
 - 2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
 - 3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.
- B. Product Data: For each type of product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation, operation, and maintenance instructions including factors effecting performance.

5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Servers.
 - b. Gateways.
 - c. Routers.
 - d. Protocol analyzers.
 - e. DDC controllers.
 - f. Enclosures.
 - g. Electrical power devices.
 - h. UPS units.
 - i. Accessories.
 - j. Instruments.
 - k. Control dampers and actuators.
 - l. Control valves and actuators.
 - m. Control sensors and switches.
 6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
 7. Each submitted piece of product literature to clearly cross reference specification and drawings that submittal is to cover.
- C. Shop Drawings:
1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor, and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
 2. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - d. Unique identification of each I/O that to be consistently used between different drawings showing same point.
 - e. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - f. Narrative sequence of operation.
 3. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
 4. DDC system network riser diagram indicating the following:
 - a. Each device connected to network with unique identification for each.
 - b. Interconnection of each different network in DDC system.
 - c. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

5. DDC system electrical power riser diagram indicating the following:
 - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
 6. Monitoring and control signal diagrams indicating the following:
 - a. Control signal cable and wiring between controllers and I/O.
 - b. Point-to-point schematic wiring diagrams for each product.
 - c. Control signal tubing to sensors, switches, and transmitters.
 - d. Process signal tubing to sensors, switches, and transmitters.
 7. Color graphics indicating the following:
 - a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
 - c. Intended operator access between related hierarchical display screens.
- D. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
 2. Complete listing and description of each report, log and trend for format and timing, and events that initiate generation.
 3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outpoints.
 - d. Server failure.
 - e. Gateway failure.
 - f. Network failure.
 - g. Controller failure.
 - h. Instrument failure.
 - i. Control damper and valve actuator failure.
 4. Complete bibliography of documentation and media to be delivered to Owner.
 5. Description of testing plans and procedures.
 6. Description of Owner training.
- E. Delegated Design Submittals: For DDC system products and installation indicated as being delegated.
1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
 2. Schedule and design calculations for control dampers and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Face velocity at Project design and minimum airflow conditions.

- c. Pressure drop across damper at Project design and minimum airflow conditions.
 - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close, or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
3. Schedule and design calculations for control valves and actuators.
- a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across valve at Project design flow condition.
 - c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
4. Schedule and design calculations for flow instruments.
- a. Instrument flow range.
 - b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter, and output signal for remote control.
 - c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter, and output signal for remote control.
 - d. Pressure-differential loss across instrument at Project design flow conditions.
 - e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.11 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system.
- 1. Include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

- e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
- f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
- g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
- h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
- i. Backup copy of graphic files, programs, and databases on electronic media.
- j. List of recommended spare parts with part numbers and suppliers.
- k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.12 QUALITY ASSURANCE

- A. DDC System Manufacturer Qualifications:
 - 1. Nationally recognized manufacturer of DDC systems and products.
 - 2. DDC systems with similar requirements to those indicated for a continuous period of 10 years within time of bid.
 - 3. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
 - 4. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
 - e. Owner operator training.
- B. DDC System Provider Qualifications:
 - 1. Authorized representative of, and trained by, DDC system manufacturer.
 - 2. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.

3. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
4. Service and maintenance staff assigned to support Project during warranty period.
5. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.

1.13 WARRANTY REQUIREMENTS

- A. Warrant all work as follows:
1. BAS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BAS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner.
 2. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BAS is operational and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
 3. To ensure that the Owner will have the most current operating system provided by the manufacturer, the BAS installing contractor shall include licensing and labor costs to facilitate software/firmware updates throughout the warranty period at no charge to the Owner. These updates shall include upgrades for functional enhancements associated with the following: operator workstation software, project specific software, graphics, database, firmware updates, and all security related service packs. Written authorization by the Owner must be granted prior to the installation of these updates.
 4. The BAS installing contractor shall provide BAS remote technical support during the warranty period. The BAS installing contractor shall set up a secure remote connection to diagnose issues remotely for the HVAC systems included in this contract.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Alerton.
 2. Distech.
 3. Trane Tracer.

2.2 APPROVED CONTROL SYSTEM INSTALLING CONTRACTORS

- A. Approved BAS Installing Contractors:
1. Control Solutions, Inc.
 2. EnerTemp.
 3. Grand Valley Automation.
 4. Mall City Mechanical.
 5. Hurst Mechanical.

6. Pulse Building Services.
7. Trane West Michigan.

2.3 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
 1. DDC system consisting of high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 WEB ACCESS

- A. DDC system to be web based.
 1. Web-Based Access to DDC System:
 - a. DDC system software based on server thin-client architecture, designed around open standards of web technology. DDC system server accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
 - b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser is required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
 - c. Password-protected web access.

2.5 PERFORMANCE REQUIREMENTS

- A. Delivery of Selected Control Devices: Deliver to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. Delegated Design, Qualified Professional: Engage a qualified professional to design DDC system to satisfy requirements indicated.
 1. System Performance Objectives:
 - a. DDC system manages HVAC systems.
 - b. DDC system operates HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
 - c. DDC system responds to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
 - d. DDC system operates while unattended by an operator and through operator interaction.
 - e. DDC system records trends and transactions of events and produces report information such as performance, energy, occupancies, and equipment operation.

- C. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths complying with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- D. DDC System Speed:
1. Response Time of Connected I/O:
 - a. Update AI point values connected to DDC system at least every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - b. Update BI point values connected to DDC system at least every two seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - c. AO points connected to DDC system to begin to respond to controller output commands within two second(s). Global commands to also comply with this requirement.
 - d. BO point values connected to DDC system to respond to controller output commands within one second(s). Global commands to also comply with this requirement.
 2. Display of Connected I/O:
 - a. Update and display analog point COV connected to DDC system at least every 10 seconds for use by operator.
 - b. Update and display binary point COV connected to DDC system at least every 5 seconds for use by operator.
 - c. Update and display alarms of analog and digital points connected to DDC system within 45 seconds of activation or change of state.
 - d. Update graphic display refresh within eight seconds.
 - e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations to not exceed graphic refresh rate indicated.
- E. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.
- F. DDC System Data Storage:
1. Include capability to archive not less than 36 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
 2. Local Storage:
 - a. Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:
 - a. Provide application-based and web browser interfaces to configure, upload, download, and manage data and to service plan with storage adequate to store all data for term indicated. Cloud storage uses IT industry standard database platforms and is capable of functions described in "DDC Data Access" Paragraph.
- G. DDC Data Access:
 1. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
 2. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
- H. Future Expandability:
 1. DDC system size is expandable to an ultimate capacity of at least 1.25 times total I/O points indicated.
 2. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
 3. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.
- I. Input Point Values Displayed Accuracy: Meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
 1. Flow:
 - a. Air: Within 5 percent of design flow rate.
 - b. Air (Terminal Units): Within 5 percent of design flow rate.
 - c. Water: Within 2 percent of design flow rate.
 2. Gas:
 - a. Carbon Dioxide: Within 50 ppm.
 3. Moisture (Relative Humidity):
 - a. Air: Within 2 percent RH.
 - b. Space: Within 2 percent RH.
 - c. Outdoor: Within 2 percent RH.
 4. Pressure:
 - a. Air, Ducts and Equipment: 1 percent of instrument range.
 - b. Space: Within 1 percent of instrument range.
 - c. Water: Within 1 percent of instrument range.
 5. Temperature, Dry Bulb:
 - a. Air: Within 1 deg F.
 - b. Space: Within 0.5 deg F.
 - c. Outdoor: Within 1 deg F.
 - d. Chilled Water: Within 0.5 deg F.
 - e. Heating Hot Water: Within 1 deg F.
 - f. Temperature Difference: Within 0.1 deg F.

- g. Other Temperatures Not Indicated: Within 1 deg F.
 - 6. Temperature, Wet Bulb:
 - a. Air: Within 0.5 deg F.
 - b. Space: Within 0.5 deg F.
 - c. Outdoor: Within 1 deg F.
- J. Environmental Conditions for Controllers, Gateways, and Routers:
 - 1. Products to operate without performance degradation under ambient environmental temperature, pressure, and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure to be internally insulated, electrically heated, cooled, and ventilated as required by product and application.
- K. Environmental Conditions for Instruments and Actuators:
 - 1. Instruments and actuators to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure is internally insulated, electrically heated, and ventilated as required by instrument and application.
- L. Backup Power Source:
 - 1. Serve DDC system products that control HVAC systems and equipment served by a backup power source also from a backup power source.
- M. Continuity of Operation after Electric Power Interruption:
 - 1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems are to automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.6 SYSTEM ARCHITECTURE

- A. System architecture consisting of no more than two levels of LANs.
- B. Provide dedicated DDC system LANs that are not shared with other building systems and tenant data and communication networks.
- C. Provide modular system architecture with inherent ability to expand to not less than 1.25 times system size indicated with no impact to performance indicated.
- D. Configure architecture to minimize the need to remove and replace existing network equipment for system expansion.

- E. Make number of LANs and associated communication transparent to operator. Configure all I/O points residing on any LAN to be capable of global sharing between all system LANs.
- F. Design system to eliminate dependence on any single device for system alarm reporting and control execution. Design each controller to operate independently by performing its own control, alarm management, and historical data collection.
- G. Special Network Architecture Requirements:
 - 1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling-system air-handling unit(s). Basically, create DDC system LAN that aligns with air-handling system being controlled.

2.7 DDC SYSTEM OPERATOR INTERFACES

- A. Operator Means of System Access: Operator able to access entire DDC system through any of multiple means including, but not limited to, the following:
 - 1. Desktop and portable workstation with hardwired connection through LAN port.
 - 2. Portable operator terminal with hardwired connection through LAN port.
 - 3. Portable operator workstation with wireless connection through LAN router.
 - 4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
 - 5. Remote connection through web access.
- B. Make access to system, regardless of operator means used, transparent to operator.
- C. Network Ports: For hardwired connection of desktop or portable workstation. Network port easily accessible, properly protected, clearly labeled, and installed at the following locations:
 - 1. Each mechanical equipment room.
- D. Desktop Workstations:
 - 1. Connect Owner-furnished desktop workstation(s) to DDC system Level 1 LAN through a communications port directly on LAN or through a communications port on a DDC controller.
 - 2. Able to communicate with any device located on any DDC system LAN.
- E. Critical Alarm Reporting:
 - 1. Send operator-selected critical alarms to notify operator of critical alarms that require immediate attention.
 - 2. Send alarm notifications to multiple recipients that are assigned for each alarm.
 - 3. Notify recipients by any or all means, including email, text message, and prerecorded phone message to mobile and landline phone numbers.
- F. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any of operator interfaces indicated.

2.8 NETWORK COMMUNICATION PROTOCOL

- A. Use network communication protocol(s) that are open to Owner and available to other companies for use in making future modifications to DDC system.
- B. ASHRAE 135 Protocol:
 - 1. Use ASHRAE 135 communication protocol as sole and native protocol used throughout entire DDC system.
 - 2. DDC system to not require use of gateways except to integrate HVAC equipment and other building systems and equipment; not required to use ASHRAE 135 communication protocol.
 - 3. If used, gateways to connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
 - 4. Use operator workstations, controllers, and other network devices that are tested and listed by BTL.

2.9 SYSTEM SOFTWARE

- A. System Software Minimum Requirements:
 - 1. Real-time multitasking and multiuser operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
 - 2. Database management software to manage all data on an integrated and non-redundant basis. Additions and deletions to database are to be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
 - 3. Network communications software to manage and control multiple network communications to provide exchange of global information and execution of global programs.
 - 4. Operator interface software to include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
 - 5. Scheduling software to schedule centrally based time and event, temporary, and exception day programs.
- B. Graphic Interface Software:
 - 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
 - 2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface is to use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
 - 3. Make descriptors for graphics, points, alarms, and such modifiable through operator's workstation under password control.

4. Make graphic displays online user definable and modifiable using the hardware and software provided.
 5. Make data displayed within a graphic assignable regardless of physical hardware address, communication, or point type.
 6. Make graphics online programmable and under password control.
 7. Make points assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
 8. Penetration within a graphic hierarchy is to display each graphic name as graphics are selected to facilitate operator understanding.
 9. Provide a back-trace feature to permit operator to move upward in the hierarchy using a pointing device. Back trace to show all previous penetration levels. Include operator with option of showing each graphic full-screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
 10. Display operator accessed data on the monitor.
 11. Provide operator with ability to select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Display defined and linked graphic below that selection.
 12. Include operator with means to directly access graphics without going through penetration path.
 13. Make dynamic data assignable to graphics.
 14. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
 15. Use color, rotation, or other highly visible means, to denote status and alarm states. Make colors variable for each class of points, as chosen by operator.
 16. For operators with appropriate privilege, command points directly from display using pointing device.
 - a. For an analog command point such as set point, display current conditions and limits so operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, show valve in current state such as open or closed so operator can select alternative position using pointing device.
 - c. Include a keyboard equivalent for those operators with that preference.
 17. Help Features:
 - a. Online context-sensitive help utility to facilitate operator training and understanding.
- C. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 2. Control schematic for each of following, including a graphic system schematic representation with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.

3. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
 4. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways and other network devices.
- D. Alarm Handling Software:
1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
 2. Include first in, first out handling of alarms in accordance with alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
 3. Make alarm handling active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
 4. Alarms display is to include the following:
 - a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability is to be operator programmable and assignable on a per point basis.
 5. Direct alarms to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
 6. Send email alarm messages to designated operators.
 7. Send email, page, text, and voice messages to designated operators for critical alarms.
 8. Categorize and process alarms by class.
 - a. Class 1:
 - 1) Associated with fire, security, and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
 - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
 - 3) All conditions make an audible alarm sound and require individual acknowledgment to silence audible sound.
 - b. Class 2:
 - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
 - 2) Acknowledgement may be through a multiple alarm acknowledgment.
 - c. Class 3:
 - 1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
 - 2) Configure so each new alarm received makes an audible alarm sound that are silenced by "acknowledging" alarm or by pressing a "silence" key.

- 3) Make acknowledgement of queued alarms either on an individual basis or through a multiple alarm acknowledgement.
 - 4) Print alarms returning to normal condition without an audible alarm sound or require acknowledgment.
 - d. Class 4:
 - 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
 9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
 10. To ensure that no alarm records are lost, make it possible to assign a backup printer to accept alarms in case of failure of primary printer.
- E. Reports and Logs:
1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
 2. Setup each report so data content, format, interval, and date are operator definable.
 3. Sample and store report data on DDC controller, within storage limits of DDC controller, and then uploaded to archive on server for historical reporting.
 4. Make it possible for operators to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 5. Store reports and logs on workstations and servers hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 6. Make reports and logs readily printable and set to be print either on operator command or at a specific time each day.
- F. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.
1. All I/O: With current status and values.
 2. Alarm: All current alarms, except those in alarm lockout.
 3. Disabled I/O: All I/O points that are disabled.
 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
- G. Standard Trends:
1. Trend all I/O point present values, set points, and other parameters indicated for trending.
 2. Associate trends into groups, and setup a trend report for each group.
 3. Store trends within DDC controller and uploaded to hard drives automatically on reaching 75 percent of DDC controller buffer limit, or by operator request, or by archiving time schedule.

4. Preset trend intervals for each I/O point after review with Owner.
 5. Make trend intervals operator selectable from 5 seconds up to 60 minutes. Make minimum number of consecutive trend values stored at one time 100 per variable.
 6. When drive storage memory is full, overwrite oldest data with most recent data.
 7. Make archived and real-time trend data available for viewing numerically and graphically by operators.
- H. Custom Trends: Operator-definable custom trend log for any I/O point in DDC system.
1. Include each trend with interval, start time, and stop time.
 2. Sample and store data on DDC controller, within reaching 75 percent storage limits of DDC controller, and then uploaded to archive on server hard drives.
 3. Make data retrievable for use in spreadsheets and standard database programs.
- I. Programming Software:
1. Include programming software to execute sequences of operation indicated.
 2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
 3. Programming Software: Any of the following:
 - a. Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
 - 2) Make programming tools viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
 4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

2.10 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems where indicated, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
1. Read and view all readable object properties on non-BACnet network to BACnet network, and vice versa, where applicable.

2. Write to all writable object properties on non-BACnet network from BACnet network, and vice versa, where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet, and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs in accordance with ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media with ability to modify, download, backup, and restore gateway configuration.

2.11 DDC CONTROLLERS

- A. DDC system consisting of a combination of network controllers, programmable application controllers, and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers to perform monitoring, control, energy optimization, and other requirements indicated.
- C. DDC controllers are to use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller is capable of full and complete operation as a completely independent unit and as a part of DDC system wide distributed network.
- E. Environment Requirements:
 1. Controller hardware suitable for anticipated ambient conditions.
- F. DDC Controller Spare Processing Capacity:
 1. Include spare processing memory for each controller.
- G. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:
 1. Network Controllers:
 - a. 20 percent of each AI, AO, BI, and BO point connected to controller.
 2. Programmable Application Controllers:
 - a. Minimum Spare I/O Points per Controller:
 - 1) AIs: Three.
 - 2) AOs: Three.
 - 3) BIs: Five.
 - 4) BOs: Five.
 - 5) Option to provide universal I/O to meet spare requirements.
 3. Application-Specific Controllers:
 - a. Minimum Spare I/O Points per Controller:
 - 1) AIs: Two.
 - 2) AOs: Two.
 - 3) BIs: Two.
 - 4) BOs: Two.

5) Option to provide universal I/O to meet spare requirements.

H. I/O Point Interface:

1. Connect hardwired I/O points to network, programmable application, and application-specific controllers.
2. Protect I/O points so shorting of point to itself, to another point, or to ground will not damage controller.
3. Protect I/O points from voltage up to 24 V of any duration so that contact will not damage the controller.
4. AIs:
 - a. Include monitoring of low-voltage (0 to 10 V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. Compatible with, and field configurable to, sensor and transmitters installed.
 - c. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection for each AI.
 - e. Capable of being individually calibrated for zero and span.
 - f. Incorporate common-mode noise rejection of at least 50 dB from 0 to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
 - g. External conversion resistors are not permitted.
5. AOs:
 - a. Perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 bits or better to comply with accuracy requirements indicated.
 - b. Output signals range of 4 to 20 mA dc or 0 to 10 V dc as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. Drift is to be not greater than 0.4 percent of range per year.
 - e. External conversion resistors are not permitted.
6. BIs:
 - a. Accept contact closures and ignore transients of less than 5 ms duration.
 - b. Isolate and protect against an applied steady-state voltage of up to 180 V ac peak.
 - c. Include a wetting current of at least 12 mA to be compatible with commonly available control devices and protected against effects of contact bounce and noise.
 - d. Sense "dry contact" closure without external power (other than that provided by controller) being applied.
 - e. Pulse accumulation input points complying with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Include buffer to totalize pulses. Pulse accumulator is to accept rates of at least 20 pulses per second. Reset the totalized value to zero on operator's command.
7. BOs:
 - a. Include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures to have a minimum duration of 0.1 second and at least 180 V of isolation.
 - 2) Include electromagnetic interference suppression on all output lines to limit transients to non-damaging levels.

- 3) Minimum contact rating to be 1 A at 24 V ac.
- 4) Triac outputs to have at least 180 V of isolation and minimum contact rating of 1 A at 24 V ac.
- b. Include BOs with two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
- c. BOs to be selectable for either normally open or normally closed operation.

2.12 NETWORK CONTROLLERS

- A. General:
 1. Include adequate number of controllers to achieve performance indicated.
 2. Provide one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
 3. Include enough memory to support its operating system, database, and programming requirements with spare memory indicated.
 4. Share data between networked controllers and other network devices.
 5. Operating system of controller to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
 6. Include network controllers with a real-time clock.
 7. Controller to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller is to assume a predetermined failure mode and generate an alarm notification.
 8. Make controllers fully programmable.
- B. Communication:
 1. Network controllers communicate with other devices on DDC system Level 1 network.
 2. Network controller to also perform routing if connected to network of programmable application controllers and application-specific controllers.
- C. Operator Interface:
 1. Equip controllers with a service communications port for connection to portable operator's workstation or mobile device.
- D. Serviceability:
 1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 3. Maintain Basic Input Output System (BIOS) and programming information in event of power loss for at least 72 hours.

2.13 PROGRAMMABLE APPLICATION CONTROLLERS

- A. General:
 1. Include adequate number of controllers to achieve performance indicated.
 2. Provide enough memory to support its operating system, database, and programming requirements with spare memory indicated.
 3. Share data between networked controllers and other network devices.

4. Include controller with operating system to manage I/O communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
 5. Include controllers with a real-time clock.
 6. Controller is to continually check status of its processor and memory circuits. If an abnormal operation is detected, controller assumes a predetermined failure mode and generates an alarm notification.
 7. Fully programmable.
- B. Communication:
1. Programmable application controllers are to communicate with other devices on network.
- C. Operator Interface:
1. Equip controllers with a service communications port for connection to portable operator's workstation or mobile device.
- D. Serviceability:
1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 3. Maintain BIOS and programming information in event of power loss for at least 72 hours.

2.14 APPLICATION-SPECIFIC CONTROLLERS

- A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment or system. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.
1. Capable of standalone operation and continued control functions without being connected to network.
 2. Share data between networked controllers and other network devices.
- B. Communication: Application-specific controllers are to communicate with other application-specific controllers and devices on network, and to programmable application controllers and network controllers.
- C. Serviceability:
1. Equip controller with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
 2. Connect wiring and cable connections to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
 3. Use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.15 CONTROLLER SOFTWARE

- A. General:
 - 1. Software applications are to reside and operate in controllers. Edit applications through operator workstations or mobile devices.
 - 2. Identify I/O points by up to 30-character point name and up to 16-character point descriptor. Use same names throughout, including at operator workstations.
 - 3. Execute control functions within controllers using DDC algorithms.
 - 4. Configure controllers to use stored default values to ensure fail-safe operation. Use default values when there is a failure of a connected input instrument or loss of communication of a global point value.
- B. Security:
 - 1. Secure operator access using individual security passwords and user names.
 - 2. Passwords restrict operator to points, applications, and system functions as assigned by system manager.
 - 3. Record operator log-on and log-off attempts.
 - 4. Protect from unauthorized use by automatically logging off after last keystroke. Make the delay time operator definable.
- C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule is to consist of the following:
 - 1. Weekly Schedules:
 - a. Include separate schedules for each day of week.
 - b. Each schedule should include capability for start, stop, optimal start, optimal stop, and night economizer.
 - c. Each schedule may consist of up to 10 events.
 - d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
 - 2. Exception Schedules:
 - a. Include ability for operator to designate any day of the year as an exception schedule.
 - b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
 - 3. Holiday Schedules:
 - a. Include capability for operator to define up to 99 special or holiday schedules.
 - b. Place schedules on scheduling calendar with ability to repeated each year.
 - c. Operator able to define length of each holiday period.
- D. System Coordination:
 - 1. Include standard application for proper coordination of equipment.
 - 2. Include operator with a method of grouping together equipment based on function and location.
 - 3. Include groups that may be for use in scheduling and other applications.
- E. Binary Alarms:
 - 1. Set each binary point to alarm based on operator-specified state.

2. Include capability to automatically and manually disable alarming.
- F. Analog Alarms:
1. Provide each analog object with both high and low alarm limits.
 2. Include capability to automatically and manually disable alarming.
- G. Alarm Reporting:
1. Include ability for operators to determine action to be taken in event of an alarm.
 2. Route alarms to appropriate operator workstations based on time and other conditions.
 3. Include ability for alarms to start programs, print, be logged in event logs, generate custom messages, and display graphics.
- H. Remote Communication:
1. Include ability for system to notify operators by phone message, text message, and email in event of an alarm.
- I. Maintenance Management: Monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- J. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- K. Control Loops:
1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm to calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Make controlled variable, set point, and PID gains operator selectable.
 - e. Adaptive (automatic tuning).
- L. Staggered Start: Prevent all controlled equipment from simultaneously restarting after a power outage. Make the order which equipment (or groups of equipment) is started, along with the time delay between starts, operator selectable.
- M. Anti-Short Cycling:
1. Protect BO points from short cycling.
 2. Feature to allow minimum on-time and off-time to be selected.
- N. On and Off Control with Differential:
1. Include algorithm that allows BO to be cycled based on a controlled variable and set point.
 2. Use direct- or reverse-acting algorithm and incorporate an adjustable differential.

- O. Run-Time Totalization:
 - 1. Include software to totalize run-times for all BI points.
 - 2. Assign a high run-time alarm, if required, by operator.

2.16 ENCLOSURES

- A. General:
 - 1. House each controller and associated control accessories in single enclosure. Enclosure is to serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies, and transformers.
 - 2. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
 - 3. Individual, wall-mounted, single-door enclosures maximum of 36 inches wide and 48 inches high.
 - 4. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
 - 5. Supply each enclosure with complete set of as-built schematics, tubing, and wiring diagrams and product literature located in pocket on inside of door.
- B. Internal Arrangement:
 - 1. Arrange internal layout of enclosure to group and protect electric, and electronic components associated with controller, but not an integral part of controller.
 - 2. Arrange layout to group similar products together.
 - 3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
 - 4. Factory or shop install products, tubing, cabling, and wiring complying with requirements and standards indicated.
 - 5. Terminate field cable and wire using heavy-duty terminal blocks.
 - 6. Include spare terminals, equal to not less than 10 percent of used terminals.
 - 7. Include spade lugs for stranded cable and wire.
 - 8. Install maximum of two wires on each side of terminal.
 - 9. Include enclosure field electric power supply with toggle-type switch located at entrance inside enclosure to disconnect power.
 - 10. Include enclosure with line-voltage nominal 20 A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with 5 A circuit breaker.
 - 11. Mount products within enclosure on removable internal panel(s).
 - 12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). Nameplates are to have at least 1/4-inch- high lettering.
 - 13. Route tubing cable and wire located inside enclosure within a raceway with continuous removable cover.
 - 14. Label each end of cable, wire, and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
 - 15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

- C. Environmental Requirements:
1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
 2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction, and wind) on enclosure.
 3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
 4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
- D. Wall-Mounted, NEMA 250, Type 1:
1. NRTL listed in accordance with UL 50 or UL 50E.
 2. Construct enclosure of steel.
 3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
 4. Hinged door full size of front face of enclosure and supported using the following:
 5. Internal panel mounting hardware, grounding hardware, and sealing washers.
 6. Grounding stud on enclosure body.
 7. Thermoplastic pocket on inside of door for record Drawings and Product Data.

2.17 RELAYS

- A. General-Purpose Relays:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allen Bradley; by Rockwell Automation
 - b. Eaton
 - c. IDEC Corporation
 - d. Omron Americas
 - e. Siemens Industry, Inc., Building Technologies Division
 - f. Square D; Schneider Electric USA
 2. NRTL listed.
 3. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
 4. SPDT, DPDT, or three-pole double-throw, as required by control application.
 5. Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.
 6. Construct contacts of silver, silver alloy, or gold.
 7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
 8. Include LED indication.
 9. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.

- f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
 - 10. Equip relays with coil transient suppression to limit transients to non-damaging levels.
 - 11. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
 - 12. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.
- B. Multifunction Time-Delay Relays:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allen Bradley; by Rockwell Automation
 - b. Eaton
 - c. IDEC Corporation
 - d. Omron Americas
 - e. Siemens Industry, Inc., Building Technologies Division
 - f. Square D; Schneider Electric USA
 - 2. NRTL listed.
 - 3. Continuous-duty type, rated for at least 10 A at 240 V ac and 60 Hz.
 - 4. Relay with up to 4 programmable functions to provide on/off delay, interval, and recycle timing functions.
 - 5. Plug-in-style relay with either multi-pin or blade plug.
 - 6. Construct contacts of silver, silver alloy, or gold.
 - 7. Enclose relay in a dust-tight cover.
 - 8. Include knob and dial scale for alternative digital interface for setting delay time.
 - 9. Visual Status Indication: Power "On" and Output "On" status.
 - 10. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
 - d. Repeatability: Within 2 percent.
 - e. Recycle Time: 45 ms.
 - f. Minimum Pulse-Width Control: 50 ms.
 - g. Power Consumption: 5 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
 - 11. Equip relays with transient suppression to limit transients to non-damaging levels.
 - 12. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
 - 13. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.
- C. Latching Relays:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allen Bradley; by Rockwell Automation
 - b. Eaton
 - c. IDEC Corporation

- d. Omron Americas
 - e. Siemens Industry, Inc., Building Technologies Division
 - f. Square D; Schneider Electric USA
 2. NRTL listed.
 3. Continuous-duty type, rated for at least 10 A at 250 V ac and 60 Hz.
 4. SPDT, DPDT, or three-pole double-throw, as required by control application.
 5. Plug-in-style relay with either multi-pin or blade plug.
 6. Construct contacts of silver, silver alloy, or gold.
 7. Enclose relay in a clear transparent polycarbonate dust-tight cover.
 8. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 15 ms or less.
 - d. Dropout Time: 10 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
 9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
 10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
 11. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.
- D. Current Sensing Relays:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton
 - b. Functional Devices Inc
 - c. NK Technologies
 - d. Square D; Schneider Electric USA
 2. NRTL listed.
 3. Monitors ac current.
 4. Independent adjustable controls for pickup and dropout current.
 5. Energized when supply voltage is present and current is above pickup setting.
 6. De-energizes when monitored current is below dropout current.
 7. Dropout current is adjustable from 50 to 95 percent of pickup current.
 8. Visual indication of contact status.
 9. Include current transformer, if required for application.
 10. House current sensing relay and current transformer if required in its own enclosure. Use NEMA 250, Type 1 enclosure for indoors applications and NEMA 250, Type 4X for outdoor applications.
- E. Combination On-Off Status Sensor and On-Off Control Relays:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Functional Devices Inc
 - b. Veris Industries

2. Description:
 - a. On-off control and on-off status indication in a single device.
 - b. LED status indication of activated relay and current trigger.
 - c. Closed-Open-Auto override switch located on the load side of relay.
3. Performance:
 - a. Ambient Temperature: Minus 30 to 140 deg F.
 - b. Voltage Rating: Single-phase loads rated for 300 V ac. Three-phase loads rated for 600 V ac.
4. Status Indication:
 - a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
 - b. Current Sensor Range: As required by application.
 - c. Current Set Point: Fixed or adjustable, as required by application.
 - d. Current Sensor Output:
 - 1) Solid-state, SPDT contact rated for 30 V ac and dc and for 0.4 A.
 - 2) Solid-state, SPDT contact rated for 120 V ac and 1.0 A.
 - 3) Analog, 0 to 5 or 10 V dc.
 - 4) Analog, 4 to 20 mA, loop powered.
5. Relay: SPDT, continuous-duty coil; rated for 10-million mechanical cycles.
6. Enclosure: NEMA 250, Type 1 enclosure for indoor applications; NEMA 250, Type 4X enclosure for outdoor applications.

2.18 ELECTRICAL POWER DEVICES

- A. Control Transformers:
 1. Sizing Criteria: Size control transformers for total connected load, plus additional 50 percent of connected load for future spare capacity.
 2. Transformer Minimum Capacity: 40 VA.
 3. Protection: Provide transformers with both primary and secondary fuses. Integral circuit breaker is acceptable in lieu of fuses.
 4. Enclosure: House control transformers in NEMA 250 enclosures, type as indicated in "Performance Requirements" Article for application.

2.19 CONTROL WIRE AND CABLE

- A. Wire: Single conductor control wiring above 24 V.
 1. Wire Size: Minimum 18 AWG.
 2. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
 3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
 4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
 5. Furnish on spools.
- B. Single, Twisted-Shielded, Instrumentation Cable above 24 V:
 1. Wire Size: Minimum 18 AWG.
 2. Conductors: Twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
 3. Conductor Insulation: Type THHN/THWN or Type TFN rating.
 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.
 - b. Twisted Triad: Black, red, and white.

5. Shielding: 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 6. Outer Jacket Insulation: 600 V, 90 deg C rating, and Type TC cable.
 7. Furnish on spools.
- C. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:
1. Wire Size: Minimum 18 AWG.
 2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.
 - b. Twisted Triad: Black, red, and white.
 5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
 7. Furnish on spools.
- D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

2.20 RACEWAYS

- A. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems" and Section 26 0533.16 "Boxes and Covers for Electrical Systems" for electrical power raceways and boxes.

2.21 ACCESSORIES

- A. Control Damper Blade Limit Switches:
1. Application: Sense positive open and/or closed position of damper blades.
 2. NEMA 250, Type 13, oiltight construction. Install in instrument enclosure where required for additional environmental protection.
 3. Arrange for mounting application, and to prevent "over-center" operation.
- B. Instrument Enclosures:
1. Application: Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
 2. Certification: NRTL listed and labeled to UL 50 or UL 508A as applicable.
 3. Identification: Include on face of enclosure an engraved, laminated phenolic nameplate for each instrument installed within enclosure.
 4. Raceways: For enclosures housing multiple instruments, route tubing, cable, and wiring within enclosure in a raceway having continuous removable cover.
 5. Access: Provide enclosures larger than 12 inches with hinged full-size face cover.

2.22 IDENTIFICATION

- A. Control Equipment, Instruments, and Control Devices:
 - 1. Self-adhesive label bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
 - 2. Letter size as follows: Minimum of 0.25 inch high.
- B. Valve Tags:
 - 1. Brass tags and brass chains attached to valve.
 - 2. Tag Size: Minimum 1.5 inches in diameter.
 - 3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
 - 4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.
- C. Equipment Warning Labels:
 - 1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
 - 2. Lettering size at least 14-point type with white lettering on red background.
 - 3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
 - 4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- E. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 - 1. DDC system has communication interface with equipment having integral controls and having communication interface for remote monitoring or control.
 - 2. Equipment to Be Connected:
 - a. Chillers specified in Section 23 6423.13 "Air-Cooled, Scroll Water Chillers."
 - b. Variable-frequency controllers specified in Section 26 2923 "Variable-Frequency Motor Controllers."
- B. Communication Interface to Other Building Systems:
 - 1. DDC system communicates with systems having communication interface.
 - 2. Systems to Be Connected:
 - a. Automated water treatment systems specified in Section 23 2516 "Water Treatment for Open-Loop Hydronic Systems."

3.3 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

- A. Interface with Existing Systems:
 - 1. Interface DDC systems with existing systems to achieve integration indicated.
 - 2. Integration of Existing Control System into DDC System:
 - a. Satisfy existing control system performance requirements when monitoring and controlling existing control system through DDC system.
 - b. Operator to upload, download, monitor, alarm, report, trend, control, and program every I/O point in existing system from DDC system using operator workstations and software provided. Combined systems to share one database.
 - c. Make interface of existing control system I/O points into DDC system transparent to operators. Make all operational capabilities identical regardless of whether I/O already exists, or I/O is being installed.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
 - 1. Control dampers, which are specified in Section 23 0923.12 "Control Dampers."
 - 2. Airflow sensors and switches, which are specified in Section 23 0923.14 "Flow Instruments."
 - 3. Pressure sensors, which are specified in Section 23 0923.23 "Pressure Instruments."
- C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.
 - 1. Control valves, which are specified in Section 23 0923.11 "Control Valves."

2. Pipe-mounted flow meters, which are specified in Section 23 0923.14 "Flow Instruments."
3. Pipe-mounted sensors, switches, and transmitters. Flow meters are specified in Section 23 0923.14 "Flow Instruments."
4. Tank-mounted sensors, switches, and transmitters. Pressure sensors, switches, and transmitters are specified in Section 23 0923.23 "Pressure Instruments."
5. Liquid temperature sensors, switches, and transmitters are specified in Section 23 0923.27 "Temperature Instruments."
6. Pipe- and tank-mounted thermowells. Liquid thermowells are specified in Section 23 0923.27 "Temperature Instruments."

3.5 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring, and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to force.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 07 8413 "Penetration Firestopping."
- G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 07 9200 "Joint Sealants."
- H. Fastening Hardware:
 1. Wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.6 INSTALLATION OF GATEWAYS

- A. Install gateways if required for DDC system communication interface requirements indicated.
 - 1. Install gateway(s) required to suit indicated requirements.
- B. Test gateways to verify that communication interface functions properly.

3.7 INSTALLATION OF CONTROLLERS

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply.
- C. Install controllers with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of network controllers to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Locate top of controller within 72 inches of finished floor.
- F. Installation of Programmable Application Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of programmable application controllers to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
 - 3. Locate top of controller within 84 inches of finished floor, except where dedicated controllers are installed at terminal units.
- G. Application-Specific Controllers:
 - 1. DDC system provider and DDC system manufacturer to determine quantity and location of application-specific controllers to satisfy requirements indicated.
 - 2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.8 INSTALLATION OF ENCLOSURES

- A. Attach wall-mounted enclosures to wall using the following types of steel struts:
 - 1. For NEMA 250 Enclosures: Type 1; use galvanized-steel strut and hardware.
 - 2. For NEMA 250 Enclosures and Enclosures Located Outdoors: Type 4; use stainless steel strut and hardware.
 - 3. Install plastic caps on exposed cut edges of strut.
- B. Align top or bottom of adjacent enclosures.

- C. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireways used for application are to have protection equal to NEMA 250 rating of connected enclosures.

3.9 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade to provide a fully functioning DDC system. Work is to comply with NFPA 70 and other requirements indicated.
- C. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.
- D. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems," Section 26 0533.16 "Boxes and Covers for Electrical Systems," and Section 26 0533.23 "Surface Raceways for Electrical Systems" for electrical power raceways and boxes.

3.10 INSTALLATION OF IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 26 0553 "Identification for Electrical Systems" for identification products and installation.
- B. Install unique instrument identification for each instrument connected to DDC controller.
- C. Install unique identification for each control damper and valve actuator connected to DDC controller.
- D. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.
- E. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.
- F. Warning Labels and Signs:
 - 1. Permanently attach to equipment that can be automatically started by DDC control system.
 - 2. Locate where highly visible near power service entry points.

3.11 INSTALLATION OF NETWORKS

- A. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:
 - 1. Operator workstations.
 - 2. Operator workstations and network controllers.

3. Network controllers.

- B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
1. Gateways and network controllers or programmable application controllers.
 2. Routers and network controllers or programmable application controllers.
 3. Network controllers and programmable application controllers.
 4. Programmable application controllers.
 5. Programmable application controllers and application-specific controllers.
 6. Application-specific controllers.

3.12 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.
- B. ASHRAE 135 Networks:
1. MAC Address:
 - a. Assign and document a MAC address unique to its network for every network device.
 - b. Ethernet Networks: Document MAC address assigned at its creation.
 - c. MS/TP Networks: Assign from 00 to 64.
 2. Network Numbering:
 - a. Assign unique numbers to each new network.
 - b. Provide ability for changing network number through device switches or operator interface.
 - c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
 3. Device Object Identifier Property Number:
 - a. Assign unique device object identifier property numbers or device instances for each device network.
 - b. Provide for future modification of device instance number by device switches or operator interface.
 - c. LAN is to support up to 4,194,302 unique devices.
 4. Device Object Name Property Text:
 - a. Device object name property field to support 32 minimum printable characters.
 - b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.
 - 1) Example 1: Device object name for device controlling heating water boiler plant at Building 1000 would be "Heating Water System Bldg. 1000."
 - 2) Example 2: Device object name for VAV terminal unit controller could be "VAV Unit 102."
 5. Object Name Property Text for Other Than Device Objects:
 - a. Object name property field is to support 32 minimum printable characters.
 - b. Assign object name properties with plain-English names descriptive of application.
 - 1) Example 1: "Zone 1 Temperature."
 - 2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:
 - a. Assign object identifier property numbers according to Drawings or tables indicated.
 - b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented, and be unique for like object types within device.

3.13 INSTALLATION OF CONTROL WIRE, CABLE, AND RACEWAY

- A. Comply with NECA 1.
- B. Wire and Cable Installation:
 1. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
 2. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in a junction box.
 - b. Individual conductors in the stripped section of cable is to be slack between the clamping point and terminal block.
 3. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
 4. Install signal transmission components in accordance with IEEE C2, REA Form 511a, NFPA 70, and as indicated.
 5. Use shielded cable to transmitters.
 6. Use shielded cable to temperature sensors.
 7. Perform continuity and meager testing on wire and cable after installation.
- C. Conduit Installation:
 1. Comply with Section 26 0533.13 "Conduits for Electrical Systems," Section 26 0533.16 "Boxes and Covers for Electrical Systems," and Section 26 0533.23 "Surface Raceways for Electrical Systems" for control-voltage conductors.

3.14 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.15 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION, AND TESTING

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

- B. For each analog instrument, make three-point test of calibration for both linearity and accuracy.
- C. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
- D. Provide diagnostic and test equipment for calibration and adjustment.
 - 1. Use field testing and diagnostic instruments and equipment with an accuracy at least twice the instrument accuracy of instrument to be calibrated. For example, test and calibrate an installed instrument with accuracy of 1 percent using field testing and diagnostic instrument with accuracy of 0.5 percent or better.
- E. Calibrate each instrument in accordance with instruction manual supplied by instrument manufacturer.
- F. If after calibration the indicated performance cannot be achieved, replace out-of-tolerance instruments.
- G. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- H. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- I. Control Dampers:
 - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
 - 3. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- J. Control Valves:
 - 1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Check and document open and close cycle times for applications with cycle time less than 30 seconds.
 - 3. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- K. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

- L. Switches: Calibrate switches to make or break contact at set points indicated.
- M. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 - 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.16 DDC SYSTEM CONTROLLER CHECKOUT

- A. Verify power supply.
 - 1. Verify voltage, phase, and hertz.
 - 2. Verify that protection from power surges is installed and functioning.
 - 3. Verify that ground fault protection is installed.
 - 4. If applicable, verify if connected to backup power source.
- B. Verify that wire and cabling are properly secured to terminals and labeled with unique identification.
- C. Verify that spare I/O capacity is provided.

3.17 DDC CONTROLLER I/O CONTROL LOOP TESTS

- A. Testing:
 - 1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
 - 2. Test every I/O point throughout its full operating range.
 - 3. Test every control loop to verify that operation is stable and accurate.
 - 4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
 - 5. Test and adjust every control loop for proper operation according to sequence of operation.
 - 6. Test software and hardware interlocks for proper operation. Correct deficiencies.
 - 7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.
 - 8. Exercise each binary point.
 - 9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller, and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller, and at field instrument must match.
 - 10. Prepare and submit report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.18 DDC SYSTEM VALIDATION TESTS

- A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
- B. After review of Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
- C. After testing is complete, submit completed Pretest Checklist.
- D. Pretest Checklist: Submit the following list with items checked off once verified:
 - 1. Detailed explanation for any items that are not completed or verified.
 - 2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
 - 3. Required DDC system components, wiring, and accessories are installed.
 - 4. Control electric power circuits operate at proper voltage and are free from faults.
 - 5. DDC system network communications function properly, including uploading and downloading programming changes.
 - 6. Using BACnet protocol analyzer, verify that communications are error free.
 - 7. Each controller's programming is backed up.
 - 8. Equipment, products, tubing, wiring cable, and conduits are properly labeled.
 - 9. All I/O points are programmed into controllers.
 - 10. Testing, adjusting, and balancing work affecting controls is complete.
 - 11. Dampers and actuators zero and span adjustments are set properly.
 - 12. Each control damper and actuator goes to failed position on loss of power.
 - 13. Valves and actuators zero and span adjustments are set properly.
 - 14. Each control valve and actuator goes to failed position on loss of power.
 - 15. Meter, sensor, and transmitter readings are accurate and calibrated.
 - 16. Control loops are tuned for smooth and stable operation.
 - 17. View trend data where applicable.
 - 18. Each controller works properly in standalone mode.
 - 19. Safety controls and devices function properly.
 - 20. Interfaces with fire-alarm system function properly.
 - 21. Electrical interlocks function properly.
 - 22. Record Drawings are completed.
- E. Test Plan:
 - 1. Address all specified functions of DDC system and sequences of operation in Test Plan.
 - 2. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
 - 3. Explain method for simulating necessary conditions of operation used to demonstrate performance.
- F. Validation Test:
 - 1. Verify operating performance of each I/O point in DDC system.
 - a. Verify analog I/O points at operating value.
 - b. Make adjustments to out-of-tolerance I/O points.
 - 1) Identify I/O points for future reference.

- 2) Simulate abnormal conditions to demonstrate proper function of safety devices.
 - 3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. 24 hours after initial validation test, do as follows:
 - a. Re-check I/O points that required corrections during initial test.
 - b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. 24 Hours after second validation test, do as follows:
 - a. Re-check I/O points that required corrections during second test.
 - b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

3.19 FINAL REVIEW

- A. Submit written request to Architect, Commissioning Agent and Construction Manager when DDC system is ready for final review. State the following:
 1. DDC system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 4. DDC system is complete and ready for final review.
- B. Upon receipt of written request for final review, Commissioning Agent and Construction Manager to start review within reasonable period and upon completion issue field report(s) documenting observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in reviewer's field report(s) and submit second written request after all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Prepare and submit closeout submittals when no deficiencies are reported.
- E. Part of DDC system final review to include demonstration to parties participating in final review.
 1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.

2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration to include, but not be limited to, the following:
 - a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 - b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points to be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
 - c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
 - d. Operation of randomly selected dampers and valves in normal-on, normal-off, and failed positions.
 - e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
 - f. Trends, summaries, logs, and reports set up for Project.
 - g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
 - h. Software's ability to communicate with controllers, operator workstations, and uploading and downloading of control programs.
 - i. Software's ability to edit control programs offline.
 - j. Data entry to show Project-specific customizing capability including parameter changes.
 - k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - l. Execution of digital and analog commands in graphic mode.
 - m. Spreadsheet and curve plot software and its integration with database.
 - n. Online user guide and help functions.
 - o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
 - p. System speed of response compared to requirements indicated.
 - q. For Each Controller: Applies to network and programmable application controllers.
 - 1) Memory: Programmed data, parameters, trend, and alarm history collected during normal operation are not to be lost during power failure.
 - 2) Operator Interface: Ability to connect directly to each type of digital controller with portable workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

- 3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
- 4) Network Communication: Ability to locate controller's location on network and communication architecture matches Shop Drawings.
- 5) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
- r. For Each Operator Workstation:
 - 1) I/O points lists agree with naming conventions.
 - 2) Graphics are complete.
- s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.

3.20 EXTENDED OPERATION TEST

- A. Operate DDC system for operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.
- B. Provide operator familiar with DDC system installed to man an operator workstation during eight hours of each normal business day occurring during operating period.
- C. During operating period, DDC system to demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.
 1. Correct defects of hardware and software when they occur.
- D. Definition of Failures and Downtime during Operating Period:
 1. Failed I/O point constituting downtime is I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.
 2. Downtime is when any I/O point in DDC system is unable to fulfill its required function.
 3. Calculate downtime as elapsed time between detected point failure as confirmed by operator, and time point is restored to service.
 4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation is to be 0.5 hours.
 5. Log downtime in hours to nearest 0.1 hour.
 6. Power outages do not count as downtime, but do suspend test hours unless systems are provided with UPS and served through a backup power source.
 7. Hardware or software failures caused by power outages do count as downtime.
- E. During operating period, log downtime and operational problems are encountered.
 1. Identify source of problem.
 2. Provide written description of corrective action taken.
 3. Record duration of downtime.
 4. Maintain log showing the following:
 - a. Time of occurrence.

- b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
 - c. Downtime for each failed I/O point.
 - d. Running total of downtime and total time of I/O point after each problem has been restored.
 5. Make log available to Owner for review at any time.
- F. For DDC system to pass extended operation test, total downtime is limited to 2 percent of total point-hours during operating period.
1. If DDC system testing results fail to comply with minimum requirements of passing at end of operating period indicated, extend operating period one consecutive day at a time until DDC system passes requirement.
- G. Base evaluation of DDC system passing test on the following calculation:
1. Count downtime on point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
 2. One point-hour of downtime is one I/O point down for one hour. For example, three I/O points down for five hours is total of 15 point-hours of downtime. Four points down for one-half hour is two point-hours of downtime.
 3. Example Calculation: Maximum allowable downtime for 30-day test for DDC system with 1000 total I/O points (combined analog and binary) and passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

3.21 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.22 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, verify that maintenance service includes 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration, and adjusting as required for proper operation. Use only manufacturer's authorized replacement parts and supplies.

3.23 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
 1. Training will be provided for the personnel designated by the Owner.
 2. Training shall include a building tour identifying the location of all major control panels and critical control devices.

- B. Extent of Training:
 - 1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 - 3. Minimum Training Requirements:
 - a. Provide not less than eight (8) hours of training total.
 - b. Stagger training over multiple sessions to accommodate Owner's requirements. All training to occur before end of warranty period.
- C. Training Schedule:
 - 1. Schedule training to provide Owner with at least 10 business days of notice in advance of training.
- D. Instructor Requirements:
 - 1. One or multiple qualified instructors, as required, to provide training.
- E. Training Outline:
 - 1. Submit training outline for Owner review at least 10 business day before each scheduling training.
- F. Minimum Training Content for Daily Operators:
 - 1. Operating operator workstations, printers, and other peripherals.
 - 2. Logging on and off system.
 - 3. Basic operation of system.
 - 4. Understanding DDC system architecture and configuration.
 - 5. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
 - 6. Understanding each unique product type installed including performance and service requirements for each.
 - 7. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
 - 8. Accessing graphics, reports, and alarms.
 - 9. Adjusting and changing set points and time schedules.
 - 10. Recognizing DDC system malfunctions.
 - 11. Understanding content of operation and maintenance manuals including control drawings.
 - 12. Understanding physical location and placement of DDC controllers and I/O hardware.
 - 13. Operating portable operator workstations.
 - 14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
 - 15. Running each specified report and log.
 - 16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.

17. Executing digital and analog commands in graphic mode.
 18. Demonstrating DDC system performance through trend logs and command tracing.
 19. Demonstrating scan, update, and alarm responsiveness.
 20. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
 - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
 - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
 - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
 - f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
 - g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.
- G. Training Content for Advanced Operators (BAS Troubleshooting & Maintenance):
1. Making and changing workstation graphics.
 2. Creating, deleting, and modifying alarms including annunciation and routing.
 3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
 4. Creating, deleting, and modifying reports.
 5. Creating, deleting, and modifying points.
 6. Creating, deleting, and modifying system graphics and other types of displays.
 7. Adding DDC controllers and other network communication devices such as gateways and routers.
 8. Adding operator workstations.
 9. Performing operator workstation operation and maintenance procedures.
 10. Configuring DDC system hardware including controllers, workstations, communication devices, and I/O points.
 11. Adjusting, calibrating, and replacing DDC system components.
- H. Training Content for System Managers and Administrators:
1. Understanding password and security procedures.
 2. Adding new operators and making modifications to existing operators.
 3. Operator password assignments and modification.
 4. Operator authority assignment and modification.
 5. Workstation data segregation and modification.
 6. DDC system software maintenance and backups.

7. Uploading, downloading, and offline archiving of all DDC system software and databases.
8. Interface with Project-specific, third-party operator software.

END OF SECTION 23 0923

SECTION 23 0923.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ball-style control valves.
 - 2. Electric and electronic control valve actuators.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 DEFINITIONS

- A. Cv: Valve coefficient.
- B. DDC: Direct digital control.
- C. EPT: Ethylene-propylene terpolymer rubber.
- D. HNBR: Hydrogenated nitrile butadiene rubber.
- E. NBR: Nitrile butadiene rubber.
- F. PEEK: Polyether Ether Ketone rubber.
- G. PTFE: Polytetrafluoroethylene.
- H. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- I. RTFE: Glass-fiber-reinforced PTFE.
- J. TFM: A chemically modified PTFE.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Ball-style control valves.
 - 2. Electric and electronic control valve actuators.

- B. Delegated Design Submittals:
 - 1. Schedule and design calculations for control valves and actuators, including the following:
 - a. Flow at project design and minimum flow conditions.
 - b. Pressure differential drop across valve at project design flow condition.
 - c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst-case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Code Compliance: Comply with governing energy code.
- D. Delegated Design: Engage a qualified professional, as defined in Section 01 4000 "Quality Requirements," to size products where indicated as delegated design.
- E. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.
- F. Backup Power Source: Serve control valve actuators from a backup power source where associated with systems and equipment served by a backup power source.
- G. Selection Criteria:
 - 1. Suitable for operation throughout full range of system operating conditions encountered.
 - 2. Control Valve Leakage: FCI 70-2, Class IV or less leakage, unless otherwise indicated.
 - 3. Control Valve Pattern: Straight-through or Three-way, as indicated on Drawings.
 - 4. Control Valve Flow Characteristics, Unless Otherwise Indicated:
 - a. Modulating, Two-Way Pattern: Equal percentage.
 - b. Modulating Three-Way Pattern: Linear flow. Total flow through the valve to be constant regardless of the valve's position.

5. Fail-Safe Positions, Unless Otherwise Indicated:
 - a. Chilled Water: Close.
 - b. Heating Hot Water: Open.
 6. Stable Operation: Select control valves and actuators for stable operation throughout full range of operation, from design Cv at design flow to minimum Cv.
 7. Control Valve Styles:
 - a. Hydronic Systems:
 - 1) Pipe Sizes NPS 2 1/2 and Smaller: Ball-style control valves.
- H. Sizing Criteria: Unless otherwise indicated, select control valve size using the following:
1. ISA Standards:
 - a. Control Valve Sizes and Flow Coefficients: ISA 75.01.01.
 - b. Control Valve Characteristics and Rangeability: ISA 75.11.01.
 2. Correction Factors: Consider viscosity, flashing, and cavitation corrections when selecting control valves.
 3. Modulating Control Valves in Hydronic Systems:
 - a. Select modulating control valve sizes at terminal equipment for a design Cv based on a pressure drop of 3 to 5 psig at design flow.

2.2 BALL-STYLE CONTROL VALVES

- A. Ball Valves with Characterized Disk and Threaded Ends, Two Way:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belimo Aircontrols (USA), Inc
 2. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: 75 percent open.
 - c. Flow Characteristic: Equal percentage.
 - d. Leakage: FCI 70-2, Class IV or less.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1-1/4 (DN 32) and Smaller: Nominal 600 psig.
 - 2) Rating for Sizes NPS 1-1/2 through NPS 2 (DN 38 through DN 50): Nominal 400 psig.
 - 3) Close-off Pressure: 200 psig.
 - f. Hydronic Process Temperature Range: 0 to 250 deg F.
 - g. Rangeability: 300 to 1.
 3. Construction:
 - a. Size Range: NPS 1/2 to NPS 2.
 - b. Body: Cast bronze or forged brass with nickel plating.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: Chrome-plated brass or bronze.
 - e. Ball Seats: Reinforced PTFE.
 - f. Characterizing Disk: Tefzel or stainless steel.
 - g. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension.

- 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
 - h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
- B. Ball Valves with Characterized Disk and Threaded Ends, Three Way:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belimo Aircontrols (USA), Inc
 - 2. Performance:
 - a. Stem Action: Rotary, 0 to 90 degrees.
 - b. Controllable Flow Range: 75 percent open.
 - c. Flow Characteristics:
 - 1) A-Port: Equal percentage.
 - 2) B-Port: Modified for constant common port flow.
 - d. Leakage: FCI 70-2, Class IV or less for A-port; one percent for B-port.
 - e. Hydronic Pressure:
 - 1) Rating for Sizes NPS 1 (DN 25) and Smaller: Nominal 600 psig.
 - 2) Rating for Sizes NPS 1-1/4 through NPS 2 1/2: Nominal 400 psig.
 - 3) Close-off Pressure: 200 psig.
 - f. Hydronic Process Temperature Range: 0 to 250 deg F.
 - g. Rangeability: 300 to 1.
 - 3. Construction:
 - a. Size Range: NPS 1/2 to NPS 2 1/2.
 - b. Body: Cast bronze or forged brass with nickel plating.
 - c. End Connections: Female threaded (NPT) ends.
 - d. Ball: Chrome-plated brass or bronze.
 - e. Ball Seats: Reinforced PTFE.
 - f. Characterizing Disk: Tefzel or stainless steel.
 - g. Stem and Stem Extension:
 - 1) Material to match ball.
 - 2) Blowout-proof design.
 - 3) For valves installed in insulated piping systems, provide stem extension.
 - 4) Provide sleeve or other approved means to allow valve to be opened and closed without damaging the insulation and the insulation vapor barrier seal.
 - h. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.

2.3 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belimo Aircontrols (USA), Inc

- B. Actuators for Control Valves in Hydronic Systems: Select actuators to close off against system pump shutoff head.
- C. Type: Motor operated, with or without gears, electric and electronic.
- D. Voltage:
 - 1. Voltage selection is delegated to professional designing control system.
 - 2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - 3. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.
- E. Construction:
 - 1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2. 100 up to 400 W: Ground steel gears, oil immersed; shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- F. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.
- G. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- H. Modulating Actuators:
 - 1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2. Control Input Signal:
 - a. Proportional: Actuator drives proportionally to input signal, modulates throughout its angle of rotation, and is suitable for zero to 10 Vdc or 4 to 20 mA signals.
- I. Position Feedback:
 - 1. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
 - 2. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- J. Fail-Safe:
 - 1. Where indicated, provide actuator to fail to an end position.
 - 2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
 - 3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.

- K. Integral Overload Protection:
 - 1. Provide against overload throughout the entire operating range in both directions.
 - 2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- L. Valve Attachment:
 - 1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve stem without the need for connecting linkages.
 - 2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 - 3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.
- M. Temperature and Humidity:
 - 1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
 - 2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from 5 to 95 percent relative humidity, noncondensing.
- N. Enclosure:
 - 1. Suitable for ambient conditions encountered by application.
- O. Stroke Time:
 - 1. Select operating stroke time to be compatible with equipment and system operation, and as follows:
 - a. Operate valve from fully closed to fully open position within 30 seconds.
 - b. Move valve to fail-safe position within 5 seconds.
- P. Sound: Where actuators are located in tenant-occupied rooms with a room sound level criteria of NC-35 or lower, comply with the following sound levels:
 - 1. Spring Return: 45 dBA.
 - 2. Nonspring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

- A. Control Valves:
 - 1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support control valves and actuators, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic event, wind, or other forces common to the application.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Seal penetrations made in fire-rated and acoustically rated assemblies.
- F. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 CONTROL VALVES

- A. Install pipe reducers for control valves smaller than line size. Position reducers as close to control valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Valve Orientation:
 - 1. Where possible, install ball valves that are installed in horizontal piping, with stems upright and not more than 15 degrees off of vertical, not inverted.
 - 2. Install valves in a position to allow full stem movement.

- D. Clearance:
 - 1. Locate valves for easy access, and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
 - 2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.
- E. Threaded Valves:
 - 1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
 - 2. Align threads at point of assembly.
 - 3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
 - 4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Use same designation at each end for each piece of wire, cable, and tubing for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with valve identification on valve. Comply with requirements in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."

3.6 ELECTRICAL CONNECTIONS

- A. Install electrical power to field-mounted control devices requiring electrical power.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.7 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.9 STARTUP

- A. Control Valve Checkout:
1. Check installed products before continuity tests, leak tests, and calibration.
 2. Check valves for proper location and accessibility.
 3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 4. Verify that control valves are installed correctly for flow direction.
 5. Verify that valve body attachment is properly secured and sealed.
 6. Verify that valve actuator and linkage attachment are secure.
 7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 8. Verify that valve ball, disc, and plug travel are unobstructed.
 9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 23 0923.11

SECTION 23 0923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Electric and electronic control-damper actuators.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data Submittals: For each damper actuator.
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Installation instructions, including factors affecting performance.
- B. Delegated Design Submittals:
 - 1. Schedule and design calculations for control dampers and actuators, including the following:
 - a. Unique designation for each damper/actuator assembly.
 - b. Service/application.
 - c. Damper assembly size.
 - d. Damper actuator action (modulating or two position).
 - e. Damper torque required at worst-case condition for sizing actuator.
 - f. Actuator selection indicating torque provided.
 - g. Actuator fail-safe position on loss of power and loss of signal.
 - h. Remarks listing special requirements.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control damper actuators.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Code Compliance: Comply with governing energy code.
- C. Delegated Design: Engage a qualified professional, as defined in Section 01 4000 "Quality Requirements," to size products where indicated as delegated design.
- D. Ground Fault: Properly ground products to prevent failing due to ground fault conditions.
- E. Backup Power Source: Serve control-damper actuators from a backup power source where associated with systems and equipment served by a backup power source.
- F. Environmental Conditions: For actuators not available with integral enclosures complying with requirements indicated, house in protective secondary enclosures complying with requirements.
- G. Selection Criteria:
 - 1. Fail-Safe Positions: As follows unless otherwise indicated on Drawings:
 - a. Supply Air: Open.
 - b. Return Air: Open.
 - c. Outdoor Air: Close.
 - d. Mixed Air: Open.
 - e. Exhaust Air: Close.
 - 2. Select damper actuators with smooth and stable operation throughout full range of operation over varying pressures and temperatures encountered.

2.2 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. Select actuators to operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Select actuators with sufficient power and torque to close off against the maximum system pressures encountered. Actuators are to be sized to close off against the fan shutoff pressure as a minimum requirement.
- C. The total damper area operated by an actuator is not to exceed 80 percent of manufacturer's maximum area rating.
- D. Provide one actuator for each damper assembly where possible. Operate multiple actuators required to drive a single damper assembly in unison.
- E. Avoid the use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- G. Provide mounting hardware and linkages for connecting actuator to damper.

- H. Select actuators to fail-safe in desired position in the event of a power and signal failure.

2.3 ELECTRIC AND ELECTRONIC CONTROL-DAMPER ACTUATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belimo Aircontrols (USA), Inc
- B. Type: Motor operated, with or without gears, electric and electronic.
- C. Voltage:
 - 1. Voltage selection is delegated to professional designing control system.
 - 2. Actuator to deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - 3. Actuator to function properly within a range of 85 to 120 percent of nameplate voltage.
- D. Construction:
 - 1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed-steel enclosures.
 - 2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains are to be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- E. Local Field Adjustment: Make spring-return actuators easily switchable from fail-safe open to fail-safe closed in the field without replacement.
- F. Local Manual Override: Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- G. Two-Position Actuators: Single direction, spring return or reversing type.
- H. Modulating Actuators:
 - 1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2. Control Input Signal:
 - a. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 0 to 10 V dc and 4 to 20 mA signals.
- I. Position Feedback:
 - 1. Equip two-position actuators with limit switches or other positive means of a position indication signal for remote monitoring of open and close position.
 - 2. Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.

3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.
- J. Fail-Safe:
 1. Where indicated, provide actuator to fail-safe to an end position.
 2. Internal spring-return mechanism to drive controlled device to an end position (open or close) on loss of power.
 3. Batteries, capacitors, and other nonmechanical forms of fail-safe operation are acceptable only where uniquely indicated.
- K. Integral Overload Protection:
 1. Provide against overload throughout the entire operating range in both directions.
 2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
- L. Damper Attachment:
 1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
 2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 3. Bolt and setscrew method of attachment is acceptable only if provided with at least two points of attachment.
- M. Temperature and Humidity:
 1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
 2. Humidity: Suitable for humidity range encountered by application; minimum operating range is to be from 5 to 95 percent relative humidity, noncondensing.
- N. Enclosure:
 1. Suitable for ambient conditions encountered by application.
- O. Stroke Time:
 1. Select operating stroke time to be compatible with equipment and system operation.
- P. Sound: Where actuators are located in tenant-occupied rooms with a room sound-level criteria of NC-35 or lower, comply with the following sound levels:
 1. Spring Return: 45 dBA.
 2. Nonspring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a seismic, wind, or other forces common to the application.
- C. Provide ceiling, floor, roof, and wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Seal penetrations made in fire-rated and acoustically rated assemblies.
- E. Fastening Hardware:
 - 1. Wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 IDENTIFICATION

- A. Install engraved phenolic nameplate with damper identification on damper.

3.4 ELECTRICAL CONNECTIONS

- A. Install electrical power to field-mounted control devices requiring electrical power.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."

3.6 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed surfaces.

3.7 STARTUP

- A. Control-Damper Checkout:
 - 1. Check installed products before continuity tests, leak tests, and calibration.
 - 2. Check dampers for proper location and accessibility.
 - 3. Verify that control dampers are installed correctly for flow direction.
 - 4. Verify that proper blade alignment, either parallel or opposed, has been provided.
 - 5. Verify that damper frame attachment is properly secured and sealed.
 - 6. Verify that damper actuator and damper linkage attachment are secure.
 - 7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 8. Verify that damper blade travel is smooth and unobstructed throughout operating range.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 23 0923.12

SECTION 23 0923.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Liquid flow meters, for chilled water systems.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 23 0993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation instructions, including factors affecting performance.
 - 5. Product certificates.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID FLOW METERS

- A. General Requirements for Liquid Flow Meters:
 - 1. Adjustable for changes in system operational parameters.
 - 2. Manufacturer is to certify that each flow instrument indicated complies with specified performance requirements and characteristics.
- B. Insertion Turbine Liquid Flow Meters:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Badger Meter, Inc.

- b. ONICON Incorporated
 - c. Spirax Sarco Limited
 2. Description: Turbine rotational sensing accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
 3. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
 4. Meter Size Range: NPS 1-1/4 through NPS 72.
 5. Process Pipe Connection: NPS 1.
 6. Performance:
 - a. Ambient Temperature: Minus 5 to plus 160 deg F.
 - b. Flow Accuracy: Within 1 percent of reading for flow velocities between 3 to 30 fps and within 2 percent of reading for flow velocities between 0.4 to 20 fps.
 - c. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 - 1) Minimum Pressure: 400 psig.
 - 2) Minimum Temperature Range:
 - a) Chilled and Condenser Water Systems: Minus 20 to plus 150 deg F.
 - b) Heating Water Systems: Within minus 20 to plus 280 deg F.
 - d. Pressure Drop: Less than 0.16 psig at 8 fps and decreasing at lower velocities.
 7. Meter Construction:
 - a. Installation Hardware: Include installation hardware necessary to enable insertion and removal from pipe without system shutdown.
 - 1) Isolation Valve: Full-port Type 316 stainless steel ball valve.
 - b. Turbines:
 - 1) Single turbines for pipe sizes NPS 2 and smaller.
 - 2) Dual turbines for pipe sizes NPS 2-1/2 and larger.
 - c. Wetted Metal Components: Type 316 stainless steel, including installation hardware.
 - d. Enclosure:
 - 1) Rating: NEMA 250, Type 4 enclosure; Type 6 for submersible applications.
 - 2) Wiring Connections: Labeled terminal strip.
 - 3) Conduit Connections: Suitable for mating to field-installed conduit.
 8. Meter Cable: As required by manufacturer for field application.
 9. Output Signals:
 - a. Analog: Field programmable, 4 to 20 mA, zero to 5 V, or zero to 10 V.
 10. Remote Display Unit:
 - a. Enclosure Rating: NEMA 250, Type 4 or 4X.
 - b. Wiring Connections: Labeled terminal strip.
 - c. Conduit Connections: 1/2-inch trade size.
 - d. Remote Signal Interface:
 - 1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero to 10 V dc.
 - 2) Outputs linear to within 0.1 percent of calibrated span.
 - 3) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.

- e. Digital Display: Backlit, LCD display of flow rate and totalized flow.
 - 1) At least eight display digits for totalization; local reset of flow totalization.
 - 2) Bidirectional units with separate digital display for flow and totalization in each direction.
 - 3) Bidirectional units with display of flow direction (contacts open or closed).
 - 11. Memory: Store program and data in nonvolatile memory.
 - 12. Power: 120 to 240 V ac; 50 to 60 Hz power supply with 24 V dc output to power the flow sensor.
- C. Clamp-On Ultrasonic Liquid Flow Sensors:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc
 - b. Badger Meter, Inc.
 - c. Dwyer Instruments, Inc
 - d. ONICON Incorporated
 - e. Spirax Sarco Limited
 - 2. Source Limitations: Obtain all clamp-on ultrasonic flow sensors from a single manufacturer.
 - 3. Description:
 - a. Flow-Sensing Method: Non-invasive with no moving parts; ultrasonic differential transit time velocity measurement using nonwetted transducers. Method is suitable for use with clear fluids in pressurized metallic and nonmetallic pipes that are full.
 - b. Programming:
 - 1) Configure and program each meter at factory for specific application without need for field programming. Field programming is available through user interface or serial interface using an operator workstation.
 - 2) Store program parameters and totalized values in nonvolatile memory.
 - c. Battery: Back-up real-time clock and calendar with lithium battery.
 - d. Data Logger: Integral data log with minimum 128 megabytes of storage.
 - 4. Factory Calibration: Factory calibrate each meter against manufacturer's NIST-traceable flow standards and provide a certificate of calibration for each meter
 - 5. Performance:
 - a. Ambient Humidity: 5 to 90 percent relative humidity, noncondensing.
 - b. Ambient Operating Temperature: Minus 5 to plus 140 deg F.
 - c. Flow Sensor Accuracy:
 - 1) Accuracy for Velocities between 1 and 20 fps: Within 1 percent of reading.
 - d. Flow Sensor Pressure Drop: No permanent pressure drop.
 - e. Flow Sensor Velocity Range: 0.07 to 40 fps.
 - f. Process Pipe Sizes: NPS 1/2 through NPS 48.
 - g. Process Temperature: Suitable for system maximum operating temperature.

6. Meter Display and Operator Interface: Backlit, LCD alphanumeric display of the following on face of meter enclosure:
 - a. Flow rate.
 - b. Power status (on/off).
7. Meter Enclosure:
 - a. Remote mounted from temperature and flow sensors.
 - b. Rating: IEC 60529 IP67 or NEMA 250, Type 4X.
 - c. Construction: Polycarbonate with hinged cover.
 - d. Electrical and Control Cable Connections: Labeled screw terminals.
 - e. Conduit Connections: Manufacturer standard; trade size suitable for mating to field-installed conduit.
8. Input Signals:
 - a. Three isolated totalizing pulse inputs for use with sinking open collector or dry contacts.
 - b. Rating: 30 V dc, 10 mA maximum.
 - c. Pulse duration of 50 ms.
 - d. For use in totalizing pulses from external devices.
 - e. Totals accumulated at meter, displayed locally and remotely through network connection.
9. Output Signals:
 - a. Flow Rate: 4 to 20 mA or zero to 10 V dc.
10. Serial Network Interface:
 - a. TIA RS-485 serial interface for remoted monitoring.
 - b. ASHRAE 135, native BACnet MS/TP protocol.
11. Power Supply:
 - a. Field Power: 24, 120, or 240 V ac; 50 or 60 Hz as required by the application.
 - b. Internal Power: As required by flow meter.
12. Transducers:
 - a. Housing: Type 316 stainless steel; NEMA 250, Type 4 with trade-size conduit connections.
 - b. Mounting Kit: Type 304 or 316 stainless steel brackets and miscellaneous hardware; option to use 200 series stainless steel clamps.
 - c. Sensor Cable: As required by manufacturer for application.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

- D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on Shop Drawings.
 - 2. Do not begin installation without submittal approval of mounting location.
- E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
- F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTRUMENT APPLICATIONS

- A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
- B. Liquid Flow Meters: For Chilled Water Systems.
 - 1. Insertion Turbine Flow Meters.
 - 2. Clamp-On Ultrasonic Flow Meters.

3.3 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- D. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 - 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.

- B. Mounting Height:
 - 1. Mount remote displays, switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.

3.5 INSTALLATION OF FLOW INSTRUMENTS

- A. Liquid Flow Meters:
 - 1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
 - 2. Insertion Meters:
 - a. Install system process connections full size of meter connection and meter manufacturer requirements, but not less than NPS 1. Provide stainless steel NPT threaded bushing if required by installation.
 - b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
 - c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

3.6 INSTALLATION OF ELECTRICAL POWER CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.7 INSTALLATION OF CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.

3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing is to have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

- B. Install engraved phenolic nameplate with instrument identification.

3.9 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.10 CHECKOUT PROCEDURES

- A. Description:
 - 1. Check out installed products before continuity tests, leak tests, and calibration.
 - 2. Check instruments for proper location and accessibility.
 - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- B. Flow Instrument Checkout:
 - 1. Verify that sensors are installed correctly with respect to flow direction.
 - 2. Verify that sensor attachment is properly secured and sealed.
 - 3. Verify that processing tubing attachment is secure and isolation valves have been provided.
 - 4. Inspect instrument tag against approved submittal.
 - 5. Verify that recommended upstream and downstream distances have been maintained.

3.11 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration are to meet instrument manufacturer's instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments are to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent needs to be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.

9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11 in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- C. Digital Signals:
 1. Check digital signals using a jumper wire.
 2. Check digital signals using an ohmmeter to test for contact.
- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Transmitters:
 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. Field calibration is not required for instruments that have been factory calibrated and provided with certificates.

3.12 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 23 0923.14

SECTION 23 0923.16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Carbon dioxide sensors and transmitters.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and other requirements that relate to this Section.
 - 2. Section 23 0923.27 "Temperature Instruments" for temperature sensors that combine gas detection into a single device.
 - 3. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Installation instructions, including factor affecting performance.
 - 3. Product description with complete technical data, performance curves, product specification sheets.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments.

PART 2 - PRODUCTS

2.1 CARBON DIOXIDE SENSORS AND TRANSMITTERS

- A. Carbon Dioxide Sensors and Transmitters, Duct Mounted:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dwyer Instruments, Inc
 - b. Honeywell Building Solutions; Honeywell International, Inc.
 - c. Telaire; a brand of Amphenol Thermometrics Inc.
 - d. Vaisala
 - 2. Description:
 - a. NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.

3. Performance:
 - a. Air Velocity Range: 0 to 2000 fpm.
 - b. Carbon Dioxide Concentration Range: Zero to 2000 ppm.
 - c. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - d. Repeatability: Within 1 percent of full scale.
 - e. Long-Term Stability: Within 5 percent of full scale after more than 5 years.
 - f. Response Time: Within 60 seconds.
 - g. Warm-up Time: Within 1 minute(s).
 - h. Ambient Temperature: 23 to 113 deg F.
 4. Output Signals:
 - a. Analog Output Signal: 4 to 20 mA or zero to 10 V dc output signal, linearized to carbon dioxide concentration in parts per million (ppm).
 5. Construction:
 - a. Enclosure: Painted metal or plastic; equivalent to NEMA 250, Type 1 or Type 4.
 - b. Electrical Connections: Screw terminals.
 - c. Visual Display: Equip with digital display for continuous indication of carbon dioxide concentration only where indicated on Drawings.
- B. Carbon Dioxide Sensors and Transmitters, Wall Mounted:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Honeywell Building Solutions; Honeywell International, Inc.
 - c. Vaisala
 2. Description:
 - a. NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
 3. Performance:
 - a. Carbon Dioxide Concentration Range: Zero to 2000 ppm.
 - b. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - c. Repeatability: Within 1 percent of full scale.
 - d. Long-Term Stability: Within 5 percent of full scale after more than 5 years.
 - e. Response Time: Within 60 seconds.
 - f. Warm-up Time: Within 5 minutes.
 - g. Ambient Relative Humidity: Zero to 95 percent noncondensing.
 - h. Ambient Temperature: 32 to 122 deg F.
 4. Output Signals:
 - a. Analog Output Signal: 4 to 20 mA or zero to 10 V dc output signal, linearized to carbon dioxide concentration in parts per million (ppm).
 5. Serial Communication: BACnet MS/TP.
 6. Construction:
 - a. Enclosure: White plastic; equivalent to NEMA 250, Type 1.
 - b. Electrical Connections: Screw terminals.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to external loads.
- D. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 - 1. Mount duct-mounted instruments at locations indicated on Drawings.
 - 2. Mount wall-mounted instruments in user-occupied space adjacent to space thermostat unless indicated otherwise on Drawings.

- B. Mounting Height:
 - 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
 - 2. Mount instruments located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.
- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems" and Section 26 0533.16 "Boxes and Covers for Electrical Systems."

3.6 IDENTIFICATION

- A. Install engraved phenolic nameplate with instrument identification on face.

3.7 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.8 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation that impacts performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration are to comply with instrument manufacturer's written instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments are to have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
 - 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 9. Comply with field-testing requirements and procedures in ASHRAE's Guideline 11, in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
- C. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- D. Transmitters: Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. Field calibration is not required for instruments that have been factory calibrated and provided with certificates.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 0923.16

SECTION 23 0923.19 - MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Moisture sensors and transmitters.
 - 2. Multifunction moisture and temperature sensors and transmitters.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and other requirements that relate to this Section.
 - 2. Section 23 0923.27 "Temperature Instruments" for temperature sensors that combine moisture, gas, and other measurements into a single device.
 - 3. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Product description with complete technical data, performance curves, and product specification sheets.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For moisture instruments.

PART 2 - PRODUCTS

2.1 MOISTURE SENSORS AND TRANSMITTERS

- A. Moisture Sensors and Transmitters for Duct Applications:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - 2. Description: Moisture measurement transmitter for use in duct and equipment applications.
 - 3. Factory Calibration: Factory calibrate each transmitter to NIST traceable standards and include transmitter with calibration certificate.

4. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) Operating Temperature Range between 32 to 122 Deg F (0 to 50 Deg C):
 - a) Within 2 percent from zero to 90 percent relative humidity.
 - b. Relative Humidity Operating Stability: Within 0.25 percent/year.
 - c. Relative Humidity Range: Zero to 100 percent.
 - d. Response Time: Within 50 seconds.
 - e. Operating Temperature Range: Select for application, but not less than minus 40 to plus 140 deg F.
 - f. Maximum Air Velocity: As required by application, but not less than 0 to 4000 fpm.
 5. Duct Probe: Plastic material listed for use in airstream with filter.
 6. Transmitter Enclosure:
 - a. Enclosure Mounting: Integral to duct probe.
 - b. Enclosure Material: Plastic or painted metal.
 - c. Enclosure Rating: NEMA 250, Type 1 or Type 4.
 7. Analog Output Signal: 4 to 20 mA or 0 to 10 V dc.
 8. Communication Network Interface: BACnet MS/TP.
 9. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.
- B. Moisture Sensors and Transmitters for Space Applications:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 2. Description: Moisture measurement transmitter for use in space applications.
 3. Factory Calibration: Factory calibrate each transmitter to NIST traceable standards and include transmitter with calibration certificate.
 4. Performance:
 - a. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) Operating Temperature Range between 32 to 104 Deg F (0 to 40 Deg C):
 - a) Within 2 percent from zero to 90 percent relative humidity.
 - b. Relative Humidity Operating Stability: Within 0.5 percent/year.
 - c. Relative Humidity Range: Zero to 100 percent.
 - d. Response Time: Within 20 seconds.
 - e. Operating Temperature Range: Select for application, but not less than 32 to 122 deg F.
 5. Transmitter Enclosure:
 - a. Enclosure Mounting: Integral to humidity sensor.
 - b. Enclosure Material: Plastic.
 - c. Enclosure Rating: NEMA 250, Type 1.
 6. Analog Output Signals: 4 to 20 mA or 0 to 10 V dc.
 7. Communication Network Interface: BACnet MS/TP.
 8. Humidity Sensor: Manufacturer's choice to comply with requirements indicated.

2.2 MULTIFUNCTION MOISTURE AND TEMPERATURE SENSORS AND TRANSMITTERS

- A. Multifunction Moisture and Temperature Sensors and Transmitters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Vaisala
 2. Description:
 - a. Factory package consisting of humidity and temperature sensors and transmitter, digital display, keypad or touchscreen display operator interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
 - b. Temperature-compensated relative humidity measurement.
 - c. Include signal conditioning and analog to digital conversion either at sensors, if offering smart sensors, or at transmitter to achieve performance indicated.
 3. Factory Calibration: Factory calibrate each transmitter to NIST traceable standards and include transmitter with calibration certificate.
 4. Performance:
 - a. Ambient Operating Temperature-Transmitter: 32 to 140 deg F.
 - b. Relative Humidity Measurement Range: Zero to 100 percent.
 - c. Relative Humidity Accuracy Including Non-Linearity, Hysteresis, and Repeatability:
 - 1) For Temperature Range between 59 to 77 Deg F:
 - a) Relative Humidity between Zero to 90 Percent: Within 1 percent.
 - b) Relative Humidity between 90 to 100 Percent: Within 1.7 percent.
 - 2) For Temperature Range between Minus 4 to Plus 104 Deg F: Within 1 percent plus 0.008 times relative humidity reading.
 - d. Relative Humidity Operating Stability: Within 0.5 percent/year.
 - e. Response Time: Within 60 seconds in still air.
 - f. Temperature Accuracy:
 - 1) Within 0.5 deg F accuracy over the temperature range of 50 to 100 deg F.
 - 2) Within 1 deg F when operating within the remainder of the temperature range.
 - g. Temperature Range: Select for application, but not less than minus 40 to plus 140 deg F.
 5. Display:
 - a. Alphanumeric display of the following parameters on the face of the enclosure:
 - 1) Percent relative humidity.
 - 2) Dry-bulb temperature.
 - b. LCD display with backlight.
 6. Transmitter Electronics Enclosure:
 - a. Enclosure Mounting: Integral to sensors for space-mounted applications unless otherwise indicated on Drawings. Install remote from temperature and humidity sensors for duct and equipment applications.
 - b. Material: Aluminum or aluminum alloy.

- c. Rating: NEMA 250, Type 4 or 4X.
 - d. Electrical Connections: Labeled terminal strip for field wiring connections.
 - e. Conduit Connections: Minimum 1/2-inch trade size, threaded.
 - f. Mounting Kit: Suitable for specific field mounting application; wall, DIN rail, pipe stand.
- 7. Programming:
 - a. Parameters are field programmable through keypad on the face of the enclosure.
 - b. Store programmed parameters in nonvolatile memory (EEPROM).
- 8. Output Signals:
 - a. Analog Output Signals: Two separate signals; 4 to 20 mA or 0 to 10 V dc. Include analog output signal for each of the following variables: Relative humidity and Dry-bulb temperature.
- 9. Communication Network Interface: BACnet MS/TP.
- 10. Humidity Sensor:
 - a. Capacitive thin-film polymer or manufacturer's choice to comply with requirements indicated.
 - b. Stainless steel sheath.
 - c. Sintered, stainless steel filter, protecting sensor.
 - d. Provide duct installation kit for duct and equipment applications.
- 11. Temperature Sensor:
 - a. Platinum RTD; 100 ohms or 1000 ohms.
 - b. Provide duct installation kit for duct and equipment applications.
- 12. Power Supply:
 - a. Field Power: 24 or 120 V ac, 60 Hz, as required by the application.
 - b. Internal Power: Manufacturer's standard, as required by transmitter and sensors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to external loads.

- C. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, verify that unrestricted ladder placement is possible during occupied condition.

3.3 INSTALLATION OF MOISTURE INSTRUMENTS

- A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
- B. Mounting Height:
 - 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height to comply with codes and accessibility requirements.
 - 2. Mount instruments located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.
- C. Seal penetrations to ductwork, plenums, and equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 ELECTRICAL CONNECTIONS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Furnish and install raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems" and Section 26 0533.16 "Boxes and Covers for Electrical Systems."

3.6 IDENTIFICATION

- A. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.8 CHECKOUT PROCEDURES

- A. Check installed products before continuity tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation that impacts performance.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration to comply with instrument manufacturer's written instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent to be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
 - 8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 9. Comply with field-testing requirements and procedures indicated by ASHRAE's Guideline 11, in the absence of specific requirements, and to supplement requirements indicated.

- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
- C. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. Field calibration is not required for instruments that have been factory calibrated and provided with certificates.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION 23 0923.19

SECTION 23 0923.23 - PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Air-pressure sensors.
 - 2. Air-pressure switches.
 - 3. Air-pressure transmitters.
 - 4. Liquid-pressure switches.
 - 5. Liquid-pressure transmitters.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct Digital Control (DDC) System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 23 0993.11 "Sequence of Operations for HVAC DDC" for sequences of operation requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over the instrument operating range, control signal over the instrument operating range, default control signal to be used by controller with loss of power to instrument, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation instructions, including factors affecting performance.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions:
1. Instruments must operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure is to be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.
 2. Protect instruments and accessories with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated are to be housed in protective secondary enclosures. Base NEMA 250 enclosure requirements on instrument-installed locations as follows:
 - a. Outdoors, Protected: Type 2.
 - b. Outdoors, Unprotected: Type 4X.
 - c. Indoors, Heated with Filtered Ventilation: Type 1.
 - d. Indoors, Heated with Nonfiltered Ventilation: Type 2.
 - e. Indoors, Heated and Air-Conditioned: Type 1.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: Type 12.
 - 2) Air-Moving Equipment Rooms: Type 2.
 - g. Localized Areas Exposed to Washdown: Type 4X.
 - h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 12.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.

2.2 AIR-PRESSURE SENSORS

- A. Air-Pressure Sensor, Static Pressure Duct Insertion Type - 90-Degree Probe Design with Compression Fitting Tubing Connection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dwyer Instruments, Inc
 2. Process Connection: Compression fitting.
 3. Construction Materials: Brass or stainless steel.
 4. Insertion Length: 4 inches.
 5. Mounting: Sensor with threaded end support, sealing washers and nuts.
 6. Pressure Measurement: Tip of sensor facing direction of airstream with four radial holes of 0.04-inch diameter.
 7. Pressure Signal Dampener: Provide sensor assembly with dampener designed to minimize erratic and rapid fluctuations in pressure signal.
 8. Duct Types: Suitable for flat oval, rectangular, and round duct configurations.

2.3 AIR-PRESSURE SWITCHES

- A. Air-Pressure Switch, Differential Type - with Set-Point Indicator:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dwyer Instruments, Inc
 2. Description: Diaphragm operated to actuate an SPDT snap switch.
 3. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. Performance:
 - a. Accuracy/Repeatability: Within 1 percent.
 - b. Electrical Rating: 15 A at 120 to 480 V ac.
 - c. Pressure Limits:
 - 1) Continuous: 10 psig.
 - 2) Surge: 25 psig.
 - d. Pressure Range: Approximately 2 times set point.
 - e. Temperature Limits: Minus 30 to plus 110 deg F.
 5. User Interface: Screw-type set-point adjustment with visible enclosed set-point indicator and scale.
 6. Process Connections: Threaded NPT, 1/8 inch.
 7. Conduit Connection: Knock out or threaded connection.
 8. Wiring Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
 9. Enclosure Material: Corrosion-resistant metal.

2.4 AIR-PRESSURE TRANSMITTERS

- A. Air-Pressure Transmitter, Differential Type - with Display:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc
 - b. Dwyer Instruments, Inc
 2. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy: Within 0.4 percent of the full-scale range.
 - c. Hysteresis: Within 0.10 percent of full scale.
 - d. Repeatability: Within 0.05 percent of full scale.
 - e. Stability: Within 0.1 percent of full scale range.
 - f. Overpressure: 10 psig.
 - g. Temperature Limits: Zero to 150 deg F.
 - h. Compensated Temperature Limits: 40 to 150 deg F.
 - i. Thermal Effects: 0.033 percent of full scale per degree F.
 - j. Transmitter is to be shock and vibration tolerant without impacting performance.
 3. Output Signals:
 - a. Analog Current Signal:
 - 1) Two-wire, 4 to 20 mA dc current source.
 - 2) Signal capable of operating into 800-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to 5 or 10 V.

- 2) Minimum Load Resistance: 1000 ohms.
4. Display: Four-digit digital display with minimum 0.4-inch- high numeric characters.
5. Operator Interface: Zero and span adjustments located on face or behind cover.
6. Construction:
 - a. Enclosure Material: Plastic enclosure with removable plastic cover.
 - b. Process Connections: Threaded, NPT swivel fittings for connection to copper tubing or barb fittings for connection to polyethylene tubing.
 - c. Wiring Connections: Screw terminal block; reverse wiring protected.
 - d. Mounting: Vertical plane mounting.
 - e. Provide mounting bracket suitable for installation.
7. Factory Calibration: Calibrate to NIST-traceable standards and provide a certificate of calibration for each transmitter.

2.5 LIQUID-PRESSURE SWITCHES

- A. Liquid-Pressure Switch, Differential Type - with Set-Point Indicator:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dwyer Instruments, Inc
 2. Description: Double opposing bellows operate to actuate a SPDT snap switch
 3. Certification: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. Performance:
 - a. Operating Pressure Range: Approximately 2 times set point.
 - b. Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
 - c. Temperature Limits: Minus 10 to plus 180 deg F.
 - d. Electrical Rating: 15 A at 120 to 240 V ac.
 5. Operator Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
 6. Construction:
 - a. Deadband: Adjustable or fixed as required by application.
 - b. Bellows: Brass or Type 316 stainless steel.
 - c. Process Connections: Threaded NPT, 1/8 inch.
 - d. Conduit Connections: Knock out or threaded connection.
 - e. Wiring Connections: Screw terminal.

2.6 LIQUID-PRESSURE TRANSMITTERS

- A. Liquid-Pressure Transmitter, Differential Type - with Field-Selectable Range and Display:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dwyer Instruments, Inc
 2. Performance:
 - a. Field-Selectable Range:
 - 1) 5, 10, 25, and 50 psig.
 - 2) 10, 20, 50, and 100 psig.
 - 3) 25, 50, 125, and 250 psig.

- b. Field-selectable unidirectional or bidirectional range.
 - c. Accuracy: Within 1 percent of the full-scale range, except lowest selectable range within 2 percent.
 - d. Stability: Within 0.5 percent of span per year.
 - e. Pressure: Maximum operating pressure equal to highest pressure in range, but not less than system design pressure.
 - f. Overpressure: Proof pressure 2 times full scale range; burst pressure 20 times full-scale range.
 - g. Ambient Temperature Limits: 32 to 122 deg F.
 - h. Compensated Temperature Limits: 32 to 130 deg F.
 - i. Thermal Effects: 2 percent of full scale per 100 deg F.
 - j. Response Time: Field selectable from 1 to 5 seconds.
 - k. Transmitter is to be shock and vibration tolerant without impacting performance.
- 3. Configurable Analog Output Current Signal:
 - a. Two-wire, 4 to 20 mA dc current source.
 - b. Signal capable of operating into 550-ohm load.
 - 4. Configurable Analog Output Voltage Signals:
 - a. Three wire, zero to 5 V, zero to 10 V.
 - b. Minimum Load Resistance: 1000 ohms.
 - 5. Display: Four-digit LCD with minimum 0.4-inch- high numeric characters.
 - 6. Operator Interface:
 - a. Digital zero button located behind cover.
 - b. Range selector located behind cover.
 - 7. Construction:
 - a. Enclosure: Cast-aluminum enclosure with removable cover.
 - b. Enclosure NEMA Rating: NEMA 250, Type 4 or 4X.
 - c. Wetted Parts: Constructed of 17-4 PH stainless steel.
 - d. Process Connections: Threaded NPT, 1/8 inch.
 - e. Conduit Connections: 1/2-inch trade-size connection.
 - f. Wiring Connections: Screw terminal block.
 - g. Mounting: Vertical plane mounting.
 - h. Mounting Bracket: Appropriate for installation.
 - 8. Three-Valve Manifold:
 - a. Construction Materials: Brass, bronze, or stainless steel.
 - b. Process Connections: Threaded NPT.
 - 9. Factory Calibration: Calibrate each transmitter to NIST-traceable standards and provide a certificate of calibration for each transmitter.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping systems to verify actual locations of connections before installation.

- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment.
- C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause damage to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.3 INSTALLATION OF PRESSURE INSTRUMENTS

- A. Mounting Location:
 - 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
 - 2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 - 3. Install liquid pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 - 4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Mounting Height:
 1. Mount remote displays, switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Mount at 60 inches.
- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- D. Duct Pressure Sensors:
 1. Install sensors using manufacturer's recommended upstream and downstream distances.
 2. Unless indicated on Drawings, locate sensors approximately 50 percent of distance of longest hydraulic run. Location of sensors is to be submitted and approved before installation.
 3. Install mounting hardware and gaskets to make sensor installation airtight.
 4. Route tubing from the sensor to transmitter.
 5. Use compression fittings at terminations.
 6. Install sensor in accordance with manufacturer's instructions.
 7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.
- E. Air-Pressure Differential Switches:
 1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
 2. A single sensor may be used to share a common signal to multiple pressure instruments.
 3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
 4. Route NPS 3/8 tubing from sensor to switch connection.
 5. Do not mount switches on rotating equipment.
 6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
 7. Install switches in an accessible location serviceable from floor.
 8. Install switches adjacent to system control panel if within 50 ft.; otherwise, locate switch in vicinity of system connection.
- F. Liquid-Pressure Switches:
 1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.

2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
 3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single location for inspection and service.
 4. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
 5. Connect process tubing from point of system connection and extend to switch.
 6. Install isolation valves in process tubing as close to system connection as practical.
 7. Install dirt leg and drain valve at each switch connection.
 8. Do not mount switches on rotating equipment.
 9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
 10. Install switches in an easily accessible location serviceable from floor.
- G. Liquid-Pressure Transmitters:
1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
 2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
 3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
 4. System process tubing connection to be full size of switch connection, but not less than NPS 1/2. Install stainless steel bushing if required to mate switch to system connection.
 5. Connect process tubing from point of system connection and extend to transmitter.
 6. Install isolation valves in process tubing as close to system connection as practical.
 7. Install dirt leg and drain valve at each transmitter connection.
 8. Do not mount transmitters on equipment.
 9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.4 ELECTRIC POWER

- A. Provide electrical power to products requiring electrical connections.
- B. Provide power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."

- D. Provide raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems."
- E. Install nameplate at each instrument electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Provide raceways. Comply with requirements in Section 26 0533.13 "Conduits for Electrical Systems" and Section 26 0533.16 "Boxes and Covers for Electrical Systems."

3.6 IDENTIFICATION

- A. Install engraved phenolic nameplate with instrument identification.

3.7 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.8 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Submit a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration must comply with instrument manufacturer's recommendations.
 - 5. Furnish diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments to have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated.
- B. Analog Signals:
1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a current meter at zero, 50, and 100 percent.
- C. Digital Signals:
1. Check digital signals using a jumper wire.
 2. Check digital signals using an ohmmeter to test for contact.
- D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.
- F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values. Field calibration is not required for instruments that have been factory calibrated and provided with certificates.

3.10 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 0923.23

SECTION 23 0923.27 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Air temperature sensors.
 - 2. Air temperature sensors with network communication signal.
 - 3. Multivariable air temperature sensors and transmitters.
 - 4. Combination air temperature sensors and switches.
 - 5. Air temperature switches.
 - 6. Air temperature RTD transmitters.
 - 7. Liquid temperature sensors.
 - 8. Liquid temperature transmitters.
- B. Related Requirements:
 - 1. Section 23 0923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 23 0993.11 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating and performance characteristics, electrical characteristics, functional characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including pressure, temperature, and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation operation and maintenance instructions, including factors affecting performance.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Environmental Conditions:
1. Instruments are to operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure is to be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.
 2. Instruments and accessories are to be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated are to be housed in protective secondary enclosures. Instrument's installed location is to dictate NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 12.
 - b. Outdoors, Unprotected: Type 4X.
 - c. Indoors, Heated with Filtered Ventilation: Type 1.
 - d. Indoors, Heated with Nonfiltered Ventilation: Type 2.
 - e. Indoors, Heated and Air Conditioned: Type 1.
 - f. Mechanical Equipment Rooms:
 - 1) Chiller and Boiler Rooms: Type 12.
 - 2) Air-Moving Equipment Rooms: Type 2.
 - g. Localized Areas Exposed to Washdown: Type 4X.
 - h. Within Duct Systems and Air-Moving Equipment not Exposed to Possible Condensation: Type 2.
 - i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
 - j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

- A. Platinum RTD, Single-Point Duct Air Temperature Sensors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 3. Performance:
 - a. Repeatability: Within 0.5 deg F.
 - b. Self-Heating: Negligible.
 - c. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.

- d. Resistance: 100 ohms or 1000 oms.
 - e. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - f. Temperature Range: As required by application, not less than Minus 40 to 185 deg F.
 - g. Accuracy: At 32 deg F within 0.27 deg F.
 4. Output Signal: Resistance in ohms.
 5. Sensor Assembly:
 - a. Probe: Single-point RTD wired within a rigid stainless steel sheath.
 - b. Length: As required by application to achieve probe tip near midpoint of air tunnel, up to 18 inches long.
 6. Gasket: For attachment to duct or equipment to seal penetration airtight.
- B. Platinum RTD, Averaging Air Temperature Sensors:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 3. Description: Multiple internal RTDs located across length of sensor probe and internally wired to signal a single average temperature reading.
 4. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 5. Performance:
 - a. Repeatability: Within 0.5 deg F.
 - b. Self-Heating: Negligible.
 - c. Resistance: 100 ohms or 1000 ohms.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than Minus 40 to 185 deg F.
 - f. Accuracy: At 32 deg F within 0.54 deg F.
 6. Output Signal: Resistance in ohms.
 7. Sensor Probe:
 - a. Type: Flexible probes; option to use averaging rigid probe sensors for air tunnels up to 36 inches.
 - b. Material:
 - 1) Flexible Probe: Copper or stainless steel.
 - 2) Rigid Probe: Stainless steel
 - c. Flexible probes formable to a minimum 4-inch radius.
 - d. Length: As required by application to account for temperature variations across entire cross section of air tunnel.
 8. Gasket: For attachment to duct or equipment to seal penetration airtight.
 9. Mounting Clips: Material to match probe; specifically designed for flexible probes to achieve radius ends when installed in serpentine arrangements.
- C. Platinum RTD Outdoor Air Temperature Sensors:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc

- b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 3. Two- or three-wire, PTFE-insulated, minimum 22-gauge stranded copper leads.
 4. Performance:
 - a. Repeatability: Within 0.5 deg F.
 - b. Self-Heating: Negligible.
 - c. Resistance: 100 ohms or 1000 ohms ohms.
 - d. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/deg C.
 - e. Temperature Range: As required by application, not less than Minus 40 to 158 deg F.
 - f. Accuracy: At 32 deg F within 0.54 deg F.
 5. Output Signal: Resistance in ohms.
 6. Sensor Assembly:
 - a. Probe: Single-point RTD wired within a stainless steel or plastic sheath.
 - b. Solar Shield: Stainless steel.
- D. Thermistor Space Air Temperature Sensors:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 2. Performance:
 - a. Temperature Drift: Within 0.5 deg F over 10 years.
 - b. Temperature Range: As required by application, not less than 32 to 122 deg F.
 - c. Interchangeable Accuracy: At 77 deg F within 0.18 deg F.
 - d. Repeatability: Within 0.5 deg F.
 - e. Self-Heating: Negligible.
 3. Output Signal: Resistance in ohms.
 4. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 5. Sensor Assembly:
 - a. Mount temperature-sensing element under a bright-white, non-yellowing, plastic enclosure.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multiconductor modular connector.

- E. Thermistor Space Air Temperature Sensors - Flush-Mount, Flat-Face Cover:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 2. Description: Sensor with flush-mounted, flat-face brushed-metal cover, intended to provide a finished appearance in areas where aesthetics is a high priority.
 3. Performance:
 - a. Temperature Drift: Within 0.5 deg F over 10 years.
 - b. Temperature Range: As required by application, not less than 32 to 122 deg F.
 - c. Interchangeable Accuracy: At 77 deg F within 0.18 deg F.
 - d. Repeatability: Within 0.5 deg F.
 - e. Self-Heating: Negligible.
 4. Output Signal: Resistance in ohms.
 5. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 6. Sensor Assembly:
 - a. Mount temperature-sensing element under a flush, brushed stainless steel flat cover plate.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
- F. Thermistor Space Air Temperature Sensors with Occupant Interface Features:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 2. Description: Sensor with integral occupant interface features.
 3. Performance:
 - a. Temperature Drift: Within 0.5 deg F over 10 years.
 - b. Temperature Range: As required by application, not less than 32 to 122 deg F.
 - c. Interchangeable Accuracy: At 77 deg F within 0.18 deg F.
 - d. Repeatability: Within 0.5 deg F.
 - e. Self-Heating: Negligible.
 4. Output Signal: Resistance in ohms.

5. Thermistor: 10000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C, Type II, negative temperature coefficient (NTC).
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
6. Sensor Assembly:
 - a. Mount temperature sensing element under a bright-white, non-yellowing, plastic cover.
 - b. Enclosure Rating: NEMA 250, Type 1.
 - c. Mounting: Provide mounting compatible with surface shape mounted to and electrical box used.
 - d. Wiring Connection: Concealed wiring connection.
 - 1) Terminal block.
 - 2) Multiconductor modular connector.
7. Occupant Interface Features: Where indicated, include instrument with the following features:
 - a. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - b. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.

2.3 AIR TEMPERATURE SENSORS WITH NETWORK COMMUNICATION SIGNAL

- A. Air Temperature Sensors with Network Communication Signal for Space Applications:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Honeywell International Inc.
 - d. Vaisala
 - e. Approved equal.
 2. Description: Air temperature sensors with network communication signal for wired connection to DDC network.
 3. Certifications: BACnet Testing Lab (BTL) certification.
 4. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 5. Performance:
 - a. Temperature:
 - 1) Accuracy: 0.5 deg F.
 - 2) Measured Range: 55 to 85 deg F.
 - 3) Ambient Operating Range: 32 to 104 deg F.
 6. Network Communication Interface: BACnet MS/TP.
 7. Temperature Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
 8. Additional Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of temperature in degrees F.
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.

9. Mounting: Concealed screw mount; compatible with mounting surface.

2.4 MULTIVARIABLE AIR TEMPERATURE SENSORS AND TRANSMITTERS

A. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Space Applications:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Vaisala
 - b. Approved equal.
2. Certifications: BACnet Testing Lab (BTL) certification.
3. Description:
 - a. Carbon-dioxide and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in applications controlling indoor, conditioned space.
4. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
5. Performance:
 - a. Carbon Dioxide:
 - 1) Carbon-Dioxide Concentration Range: Zero to 2000 ppm.
 - 2) Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3) Repeatability: Within 1 percent of full scale.
 - 4) Long-Term Stability: Within 5 percent of full scale after more than 5 years.
 - 5) Response Time: Within 60 seconds.
 - 6) Warm-up Time: Within 5 minutes.
 - b. Temperature:
 - 1) Accuracy: 0.5 deg F.
 - 2) Measured Range: 55 to 85 deg F.
 - 3) Ambient Operating Range: 32 to 104 deg F.
6. Analog Output Signal:
 - a. Carbon Dioxide: 4 to 20 mA or 0 to 10 V dc output signal, linearized to carbon-dioxide concentration in parts per million (ppm).
 - b. Temperature: 4 to 20 mA or 0 to 10 V dc.
7. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
8. Temperature Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
9. Enclosure:
 - a. Material: Plastic; bright white, non-yellowing.
 - b. Rating: NEMA 250, Type 1.
10. Additional Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of carbon-dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in degrees F.
 - b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.

11. Mounting: Concealed screw mount; compatible with mounting surface.

B. Combination Carbon-Dioxide, Relative Humidity, and Temperature Sensors and Transmitters for Space Applications:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Vaisala
 - b. Approved equal.
2. Certifications: BACnet Testing Lab (BTL) certification.
3. Description:
 - a. Carbon-dioxide, relative humidity, and air temperature sensors and transmitters combined into a single instrument for wired connection to DDC controllers.
 - b. Intended for use in applications controlling indoor, conditioned space.
4. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
5. Performance:
 - a. Carbon Dioxide:
 - 1) Carbon-Dioxide Concentration Range: Zero to 2000 ppm.
 - 2) Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3) Repeatability: Within 1 percent of full scale.
 - 4) Long-Term Stability: Within 5 percent of full scale after more than 5 years.
 - 5) Response Time: Within 60 seconds.
 - 6) Warm-up Time: Within 5 minutes.
 - b. Relative Humidity:
 - 1) Accuracy: 2 percent relative humidity.
 - 2) Calibrated Range: 20 to 80 percent relative humidity.
 - 3) Operating Stability: Within 0.5 percent/year.
 - 4) Response Time: Within 20 seconds.
 - c. Temperature:
 - 1) Accuracy: 0.54 deg F.
 - 2) Measured Range: 32 to 122 deg F.
 - 3) Ambient Operating Range: 32 to 104 deg F.
6. Analog Output Signal:
 - a. Carbon Dioxide: 4 to 20 mA or 0 to 10 V dc output signal, linearized to carbon-dioxide concentration in parts per million (ppm).
 - b. Relative Humidity: 4 to 20 mA or 0 to 10 V dc.
 - c. Temperature: 4 to 20 mA or 0 to 10 V dc.
7. Carbon-Dioxide Sensor Type: Nondispersive infrared or equivalent technology providing performance indicated, long-term stability, and reliability.
8. Relative Humidity Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
9. Temperature Sensor Type: Manufacturer's choice of sensor type to achieve performance indicated, long-term stability, and reliability.
10. Additional Features: Where indicated, include instrument with the following features:
 - a. Display: Backlit LCD display of carbon-dioxide concentration in parts per million (ppm), relative humidity in percent relative humidity, and temperature in degrees F.

- b. Occupancy Override: Local adjustment on face of enclosure for occupant to initiate zone HVAC operation.
 - c. Temperature Set Point: Local adjustment on face of enclosure for occupant to adjust zone temperature set point.
11. Mounting: Concealed screw mount; compatible with mounting surface.

2.5 AIR TEMPERATURE SWITCHES

- A. Thermostat and Switch for Low-Temperature Control in Duct Applications:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Dynacon Inc.
 - e. Honeywell International Inc.
 - 2. Description:
 - a. Two-position control to open control circuit when temperature is below set point.
 - b. Field-adjustable set point.
 - c. Reset: Manual.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Performance:
 - a. Operating Temperature Range: 15 to 55 deg F.
 - b. Temperature Differential: 2 deg F, nonadjustable and additive.
 - c. Enclosure Ambient Temperature: 20 to 140 deg F.
 - d. Sensing Element Maximum Temperature: 140 deg F.
 - e. Voltage: 120 V ac.
 - f. Current: 10 FLA.
 - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.
 - 4. Construction:
 - a. Vapor-Filled Sensing Element: Nominal 20 ft. or 50 ft. long; quantity and length of elements as required by application to account for temperature variations across entire cross section of air tunnel.
 - b. Temperature Scale: Fahrenheit visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal or plastic, NEMA 250, Type 1 or Type 4.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 1/2-inch trade size.
 - g. Mounting Clips: Copper-clad mounting clips with formed radius intended for serpentine coverage across coil face area.
- B. Thermostat and Switch for High-Temperature Control in Duct Applications:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc

- d. Dynacon Inc.
- e. Greystone Energy Systems, Inc.
- f. Honeywell International Inc.
- 2. Description:
 - a. Two-position control to open control circuit when temperature rises above set point.
 - b. Field-adjustable set point.
 - c. Automatic reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 3. Performance:
 - a. Temperature Range: 100 to 160 deg F.
 - b. Temperature Differential: 5 deg F.
 - c. Ambient Temperature: 14 to 122 deg F.
 - d. Voltage: 120 V ac.
 - e. Current: 5 FLA or 16 FLA.
- 4. Construction:
 - a. Sensing Element: Helical bimetal or 10000-ohm, Type II, NTC thermistor.
 - b. Switch Type: SPDT snap switch.
 - c. Enclosure Material: Metal or plastic.
 - d. Enclosure Rating: NEMA 250, Type 1 or Type 4X.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 1/2-inch trade size.

2.6 AIR TEMPERATURE RTD TRANSMITTERS

- A. Air Temperature RTD Transmitters:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 - e. Vaisala
 - 2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 - 3. If transmitter is not integral with sensor enclosure, house transmitter electronics in NEMA 250 enclosure based on physical location and application.
 - 4. Conduit Connection: 1/2-inch trade size.
 - 5. Functional Characteristics:
 - a. Input:
 - 1) 100-ohm platinum RTD with a temperature coefficient of resistance (TCR) of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - 2) 1000-ohm platinum RTD with a temperature coefficient of resistance (TCR) of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - b. Span (Adjustable):
 - 1) Space: 40 to 90 deg F.
 - 2) Supply Air Cooling and Heating: 40 to 120 deg F.
 - 3) Supply Air Cooling Only: 40 to 90 deg F.
 - 4) Supply Air Heating Only: 40 to 120 deg F.

- 5) Exhaust Air from Conditioned Space: 50 to 100 deg F.
- 6) Return Air: 50 to 100 deg F.
- 7) Mixed Air: Minus 40 to 140 deg F.
- 8) Outdoor: Minus 40 to 140 deg F.
- c. Minimum Span: 50 deg F.
- d. Field Adjustments: Zero and span, plus or minus 5 percent of span.
- e. Transmitter required for each 100-ohm RTD.
- f. Transmitter optional for 1000-ohm RTD, contingent on compliance with system end-to-end control accuracy.
- g. Analog Output Signal:
 - 1) Current: 4 to 20 mA dc, linear with temperature; radio-frequency-interference insensitive; minimum drive load of 600 ohms at 24 V dc.
 - 2) Voltage: 0 to 10 V dc, linear with temperature.
6. Performance Characteristics:
 - a. Calibration Accuracy: Within 0.2 percent of the span.
 - b. Stability: Within 0.2 percent of the span for at least six months.
 - c. Combined Accuracy: Within 0.5 percent.
7. Factory Match: Match sensor with temperature transmitter and factory calibrate together.

2.7 LIQUID TEMPERATURE SENSORS

- A. Platinum RTD Immersion Temperature Sensors, Commercial Grade:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
 2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
 3. Performance Characteristics:
 - a. Resistance: 100 or 1000 ohms.
 - b. Temperature Coefficient of Resistance (TCR): 0.00385 ohm/ohm/deg C.
 - c. Temperature Range: Minus 40 to 210 deg F.
 - d. Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.
 - e. Rated for system pressure, temperature, and velocity.
 4. Output Signal: Resistance in ohms.
 5. Sensor Assembly:
 - a. Probe: Single RTD wired within a rigid stainless steel sheath with a 0.25-inch OD.
 - b. Immersion Depth: 2, 2-1/2, 4, 6, or 8 inches as required by application.
 - c. Process Connection: Threaded, NPS 1/2.
 - d. Two- or three-stranded copper lead wires.
 6. Enclosure:
 - a. Material: Metal box with removable cover.
 - b. Rating: NEMA 250, Type 4 or Type 4X.
 - c. Conduit Connection: 1/2-inch or 3/4-inch trade size.

B. Thermowells, Commercial Grade:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ACI Automation; Automation Components Inc
 - b. Building Automation Products Inc.; BAPI
 - c. Dwyer Instruments, Inc
 - d. Honeywell International Inc.
2. Performance: Rated for system pressure, temperature and velocity.
3. Thermowell:
 - a. Material: Brass or stainless steel.
 - b. Process Connection: Threaded, NPS 1/2 or NPS 3/4.
 - c. Sensor Connection: Threaded, NPS 1/2.
 - d. Stem: Straight or stepped shank formed from solid bar stock.
 - e. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - f. Extended Neck: Furnish thermowells installed in insulated pipes and equipment with an extended neck.
 - g. Immersion Length: 2, 2-1/2, 4, 6, or 8 inches as required by application.
4. Furnish thermowells with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.
5. Factory Assembly: Sensor manufacturer is to furnish sensor and thermowell to provide a matched assembly.

2.8 LIQUID TEMPERATURE TRANSMITTERS**A. Liquid Temperature Transmitters, High-End Commercial Grade:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Minco
2. Factory Calibration: Factory calibrate each instrument to NIST-traceable standards and include instrument with a calibration certificate.
3. Performance Characteristics:
 - a. Calibration Accuracy: Within 0.1 percent of the span.
4. Functional Characteristics:
 - a. Input: 100-ohm platinum RTD with temperature coefficient of 0.00385 ohm/ohm/deg C; two- or three-wire sensors.
 - b. Default Span (Adjustable):
 - 1) Chilled Water: 0 to 100 deg F.
 - 2) Heating Hot Water: 32 to 212 deg F.
 - c. Minimum Span: 18 deg F
 - d. Field Adjustments: Zero and span adjustments, plus or minus 5 percent of span.
5. Analog Output Signal: 4 to 20 mA dc, linear with temperature; radio-frequency-interference insensitive; minimum drive load of 600 ohms at 24 V dc.
6. Electronics Enclosure:
 - a. Material: Painted aluminum alloy.
 - b. Rating: NEMA 250, Type 4 or Type 4X.
 - c. Conduit Connection: 1/2-inch or 3/4-inch trade size.
 - d. Wiring Connection: Labeled terminals.

- e. Display: Head mounted; display of temperature in degrees F.
- 7. Factory Match: Factory match sensor with temperature transmitter.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

- A. Air Temperature Sensors:
 - 1. 100-ohm or 1000-ohm Platinum RTD, Single-Point Air Temperature Duct Sensors: air handling system supply, return, mixed air.
 - 2. 100-ohm or 1000-ohm Platinum RTD, Air Temperature Averaging Sensors: heating and cooling coils.
 - 3. 100-ohm or 1000-ohm Platinum RTD Outdoor Air Temperature Sensors: chiller and boiler plants.
 - 4. Thermistor Space Air Temperature Sensors: spaces typically not occupied.
 - 5. Thermistor Space Air Temperature Sensors, Flush-Mount, Flat-Face Cover: typically for vestibules, corridors, or other passageways served by terminal heating units only.
 - 6. Thermistor Space Air Temperature Sensors with Occupant Interface Features: typically small, occupied spaces served by air terminal units or fan powered heating and cooling units.
- B. Air Temperature Sensors with Network Communication Signal for Space Applications: Contractor option for stand-alone space temperature sensors not associated with unit DDC controller(s).
- C. Multivariable Air Temperature Sensors and Transmitters:
 - 1. Combination Carbon-Dioxide and Air Temperature Sensors and Transmitters for Space Applications: occupied spaces requiring carbon dioxide monitoring.
 - 2. Combination Carbon-Dioxide, Relative Humidity, and Temperature Sensors and Transmitters for Space Applications: occupied spaces requiring carbon dioxide and relative humidity monitoring.

- D. Air Temperature Switches:
 - 1. Thermostat and Switch for Low-Temperature Control in Duct Applications: typically for freeze protection of air handling system water coils.
 - 2. Thermostat and Switch for High-Temperature Control in Duct Applications: typically used for high temperature limits of air handling systems.
- E. Air Temperature RTD Transmitters: where needed to provide accurate and stable temperature data to control systems, ensuring optimal comfort, energy efficiency, and reliable operation of the HVAC equipment and systems.
- F. Liquid Temperature Sensors, Commercial Grade:
 - 1. 100-ohm or 1000-ohm Platinum RTD Immersion Temperature Sensors, Commercial Grade: chilled water or heating hot water temperature monitoring and control.
- G. Liquid Temperature Transmitters, Commercial Grade: where needed to provide accurate and stable temperature data to control systems, ensuring optimal comfort, energy efficiency, and reliable operation of the HVAC equipment and systems.

3.3 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment.
- C. Fastening Hardware:
 - 1. Wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.4 INSTALLATION OF TEMPERATURE INSTRUMENTS

- A. Mounting Location:
 - 1. Roughing In:
 - a. Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 - b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.

- 2) Do not begin installation without submittal approval of mounting location.
 - c. Complete installation rough-in only after confirmation by independent inspector is complete and approval of location is documented for review by Owner and Architect on request.
 2. Install switches and transmitters for air and liquid temperature associated with individual HVAC equipment and associated connected ductwork and piping near HVAC equipment co-located in HVAC equipment system control panel to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Special Mounting Requirements:
 1. Protect products installed outdoors from solar radiation and building and wind effect with stand-offs and shields constructed of Type 316 stainless steel.
 2. Isolate temperature instruments having performance impacted by temperature of mounting substrate with an insulating barrier located between instrument and substrate to eliminate effect on performance. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
- C. Mounting Height:
 1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height is to comply with codes and accessibility requirements.
 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.
- D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- E. Installation of Space Temperature Sensors:
 1. Conceal assembly and field wiring connections in an electrical box of sufficient size to house sensor and transmitter, if provided.
 2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
 3. In finished areas, recess electrical box within wall.

4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
 5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
- F. Installation of Outdoor Air Temperature Sensors:
1. Mount sensor in an accessible and discrete location facing north.
 2. Protect installed sensor from solar radiation and other environmental influences that could impact performance.
 3. If required to have a transmitter, mount transmitter remotely from sensor in an accessible and serviceable location indoors that is not readily accessible by building occupants.
- G. Installation of Single-Point Duct Temperature Sensors:
1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed near center of duct cross section and located to sense near average temperature. Do not exceed 18 inches in sensor length.
 2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
 3. Rigidly support sensor to duct and seal penetration airtight.
 4. If required to have transmitter, mount transmitter remotely from sensor at accessible and serviceable location indoors that is not readily accessible by building occupants.
 5. Install duct access doors of sufficient size for inspection, removal, and replacement of single-point duct temperature sensors.
- H. Installation of Averaging Duct Temperature Sensors:
1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar HVAC equipment, and large ducts with air tunnel cross-sectional area of 10 sq. ft. and larger.
 2. Install sensor length to maintain coverage over entire cross-sectional area and measure an average temperature. Install multiple sensors where required to maintain coverage.
 3. Fasten and support sensor with manufacturer-furnished clips to keep sensor properly supported and taut throughout entire length.
 4. If required to have transmitter, mount transmitter in an accessible and serviceable location indoors that is not readily accessible by building occupants.
 5. Install duct access doors of sufficient size for inspection, removal, and replacement of averaging duct temperature sensors.
- I. Installation of Multivariable Air Temperature Sensors and Transmitters: Comply with requirements indicated for air temperature sensors.

- J. Installation of Low-Limit Air Temperature Switches:
1. Install low-limit switches to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification. Install multiple switches if required to maintain coverage over entire cross-sectional area of air tunnel and to account for stratification.
 2. Fasten and support sensing element with manufacturer-furnished clips to keep sensor properly supported and taut throughout entire length.
 3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
 4. Install on entering side of cooling coil unless otherwise indicated on Drawings.
 5. Install duct access doors of sufficient size for inspection, removal, and replacement of low-limit air temperature switches.
- K. Installation of Liquid Temperature Sensors:
1. Install all sensors in a matching thermowell.
 2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
 3. For pipe smaller than NPS 4:
 - a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
 - b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
 - c. Minimum insertion depth is to be 2-1/2 inches.
 4. Fill thermowell with heat-transfer compound before inserting sensor.
 5. Install tip of spring-loaded sensors to contact inside of thermowell.
 6. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
 7. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
 8. Install sensors and thermowells to provide a leak-free installation when subjected to system, pressures, temperatures, and velocities encountered.
 9. For applications with transmitters, mount transmitter remotely from sensor in an accessible and serviceable location from floor, service platform or catwalk. Avoid locations that are readily accessible by building occupants.

3.5 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."

- D. Furnish and install raceways. Comply with requirements in Section 26 0533.23 "Surface Raceways for Electrical Systems."
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.6 CONTROL CONNECTIONS

- A. Install control signal wiring to field-mounted control devices.
- B. Furnish and install raceways. Comply with requirements in Section 26 0533.23 "Surface Raceways for Electrical Systems."

3.7 IDENTIFICATION

- A. Install engraved phenolic nameplate with instrument identification.

3.8 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

3.9 CHECK-OUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check temperature instruments for proper location and accessibility.
- C. Verify sensing element type and proper material.
- D. Check instruments for proper installation with respect to location, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- E. Verify that wiring is correct and secure.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration are to meet instrument manufacturer's written instructions.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.

6. Field instruments and equipment used to test and calibrate installed instruments are to have at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent is to be checked by an instrument with an accuracy of 0.5 percent.
 7. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements and to supplement requirements indicated.
- B. Analog Signals:
1. Check analog voltage signals using a voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a current meter at zero, 50, and 100 percent.
 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.
- C. Digital Signals:
1. Check digital signals using a jumper wire.
 2. Check digital signals using an ohmmeter to test for contact.
- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.
- F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values. Field calibration is not required for instruments that have been factory calibrated and provided with certificates.
 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 FIELD QUALITY CONTROL

- A. Tests and Inspections: Perform the following tests and inspections with the assistance of a factory-authorized service representative:
1. Perform in accordance with manufacturer's written instruction.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Prepare test and inspection reports.

3.12 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.13 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.
- B. Coordinate training video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record Owner training and submit digital files with closeout documents for Owner's future use.

END OF SECTION 23 0923.27

SECTION 23 0993.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.
- B. Related Requirements:
 - 1. Section 23 0923 "DDC Systems for HVAC" for control equipment.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
 - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.
- B. Shop Drawings:
 - 1. Riser diagrams showing control network layout, communication protocol, and wire types.
 - 2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
 - 3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.3 CENTRAL HEATING CONTROL SEQUENCES

- A. Refer to sequences of operation on Drawings.

1.4 CENTRAL CHILLED-WATER SYSTEM SEQUENCES

- A. Refer to sequences of operation on Drawings.

1.5 AIR-HANDLING-UNIT CONTROL SEQUENCES

- A. Refer to sequences of operation on Drawings.

1.6 TERMINAL UNIT OPERATING SEQUENCE

- A. Refer to sequences of operation on Drawings.

1.7 VENTILATION SEQUENCES

- A. Exhaust Fan: Refer to sequences of operation on Drawings.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0993.11

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper tube and fittings.
 - 2. Steel pipe and fittings.
 - 3. Piping joining materials.
 - 4. Transition fittings.
 - 5. Dielectric fittings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
 - 1. Hot-Water Heating Piping: 100 psig at 200 deg F.
 - 2. Chilled-Water Piping: 150 psig at 73 deg F.
 - 3. Makeup-Water Piping: 80 psig at 73 deg F.
 - 4. Condensate-Drain Piping: 150 deg F.
 - 5. Air-Vent Piping: 200 deg F.
 - 6. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B88, Type K and ASTM B88, Type L.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cambridge-Lee Industries, LLC
 - b. Cerro Flow Products, LLC
 - c. Mueller Streamline Co.; a company of Mueller Industries
- B. Annealed-Temper Copper Tube: ASTM B88, Type K and ASTM B88, Type L.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cambridge-Lee Industries, LLC
 - b. Cerro Flow Products, LLC
 - c. Mueller Streamline Co.; a company of Mueller Industries

- C. DWV Copper Tube: ASTM B306, Type DWV.
- D. Cast-Copper, Solder-Joint Fittings: ASME B16.18 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.
- E. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems
 - b. Mueller Streamline Co.; a company of Mueller Industries
 - c. NIBCO INC.
- F. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than NPS 4.
- G. Cast-Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends. Do not use solder joints on pipe sizes greater than NPS 4.
- H. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4.
- I. Grooved, Mechanical-Joint, Copper Tube Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Victaulic Company
 - 2. Grooved-End Copper Fittings: ASTM B75 copper tube or ASTM B584 bronze castings.
 - 3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psig minimum CWP pressure rating.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3, "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3, "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3, "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping Applications" Article.

- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.
- G. Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution
 - b. Victaulic Company
 - 2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B32, lead-free alloys.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Flux: ASTM B813, water flushable.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jomar Valve
 - b. Matco-Norca
 - c. WATTS; A Watts Water Technologies Company
 - d. Wilkins
 - e. Zurn Industries, LLC
 - 2. Source Limitations: Obtain dielectric unions from single manufacturer.
 - 3. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are not to be used on pipe sizes greater than NPS 4.
- C. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. WATTS; A Watts Water Technologies Company
 - b. Wilkins
 - c. Zurn Industries, LLC
 - 2. Source Limitations: Obtain dielectric flanges from single manufacturer.
 - 3. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric Nipples:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Matco-Norca

- c. Precision Plumbing Products
- d. Sioux Chief Manufacturing Company, Inc.
- e. Victaulic Company
- 2. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F1545.
 - c. Pressure Rating: Minimum 300 psig at 225 deg F.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-Water Heating Piping, Aboveground, NPS 2 and Smaller:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 and Larger, to Be Any of the Following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and grooved mechanical joints.
 - 2. Schedule 40, Grade B, steel pipe; Class 125, cast-iron fittings; welded joints, cast-iron flanges, flange-fittings, and flanged joints.
 - 3. Schedule 40, Grade B, steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
- C. Chilled-Water Piping, Aboveground, NPS 2 and Smaller:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- D. Chilled-Water Piping, Aboveground, NPS 2-1/2 and Larger, to Be Any of the Following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and grooved mechanical joints.
 - 2. Schedule 40, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - 3. Schedule 40, Grade B, steel pipe; grooved mechanical joint coupling and fittings; and grooved mechanical joints.
- E. Makeup-Water Piping Installed Aboveground to Be Any of the Following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- F. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 - 2. Schedule 40, PVC plastic pipe and fittings and solvent-welded joints.

- G. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, in accordance with piping manufacturer's written instructions.
 - 2. Outlet: Type L, annealed-temper copper tubing with soldered or flared joints.
- H. Pressure-Relief-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed, with metal-to-plastic transition fittings for plastic piping systems, in accordance with piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves in accordance with Section 23 0523 "General-Duty Valves for HVAC Piping."
- Q. Install air vents and pressure-relief valves in accordance with Section 23 2116 "Hydronic Piping Specialties."
- R. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- T. Install shutoff valve immediately upstream of each dielectric fitting.
- U. Comply with requirements in Section 23 0500 "Common Work Results for HVAC" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- V. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for identifying piping.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 0500 "Common Work Results for HVAC."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 0500 "Common Work Results for HVAC."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- E. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.4 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples or unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- B. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- C. Support horizontal piping within 12 inches of each fitting and coupling.
- D. Support vertical runs of copper tubing and steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 0500 "Common Work Results for HVAC."

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 23 0553 "Identification for HVAC Piping and Equipment."

3.8 SYSTEM STARTUP

- A. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect pumps for proper rotation.
 - 3. Set makeup pressure-reducing valves for required system pressure.
 - 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).

5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers to specified values.
7. Verify lubrication of motors and bearings.

3.9 FIELD QUALITY CONTROL

- A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.

END OF SECTION 23 2113

SECTION 23 2116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hydronic specialty valves.
 - 2. Air vents.
 - 3. Expansion tanks and fittings.
 - 4. Air separators.
 - 5. Chilled water buffer tanks.
 - 6. Strainers.
 - 7. Flexible connectors.
- B. Related Requirements:
 - 1. Section 23 0500 "Common Work Results for HVAC" for expansion fittings and loops.
 - 2. Section 23 0523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for general-duty valves common to most piping systems.
 - 3. Section 23 0923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product:
 - 1. Include construction details and material descriptions for hydronic piping specialties.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.

- B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett; a Xylem brand
 - b. Tour & Andersson; available through Victaulic Company
 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Plug: Resin.
 5. Seat: PTFE.
 6. End Connections: Threaded or socket.
 7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 8. Handle Style: Lever, with memory stop to retain set position.
 9. CWP Rating: Minimum 125 psig.
 10. Maximum Operating Temperature: 250 deg F.
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett; a Xylem brand
 2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Stem Seals: EPDM O-rings.
 5. Disc: Glass- and carbon-filled PTFE.
 6. Seat: PTFE.
 7. End Connections: Flanged or grooved.
 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 9. Handle Style: Lever, with memory stop to retain set position.
 10. CWP Rating: Minimum 125 psig.
 11. Maximum Operating Temperature: 250 deg F.
- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Bell & Gossett; a Xylem brand
 - c. Jenkins Valves; a Crane Co. brand
 - d. NIBCO INC.
 - e. Taco Comfort Solutions
 - f. WATTS; A Watts Water Technologies Company

- g. Zurn Industries, LLC
 2. Body: Bronze or brass.
 3. Disc: Brass.
 4. Seat: Brass.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPDM.
 7. Low inlet-pressure check valve.
 8. Inlet Strainer: removable without system shutdown.
 9. Valve Seat and Stem: Noncorrosive.
 10. Valve Size and Capacity: As indicated on Drawings.
 11. Operating Pressure: Factory set and field adjustable.
- D. Diaphragm-Operated Pressure-Relief Valves: ASME labeled.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Bell & Gossett; a Xylem brand
 - c. WATTS; A Watts Water Technologies Company
 - d. Zurn Industries, LLC
 2. Body: Bronze or brass.
 3. Disc: Brass.
 4. Seat: Brass.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPDM.
 7. Valve Seat and Stem: Noncorrosive.
 8. Valve Size, Capacity, and Operating Pressure: Comply with ASME BPVC, Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- E. Automatic Flow-Control Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett; a Xylem brand
 - b. Victaulic Company
 2. Body: Brass or ferrous metal.
 3. Combination Assemblies: Include bronze or brass-alloy ball valve.
 4. Identification Tag: Marked with zone identification, valve number, and flow rate.
 5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
 6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
 7. Minimum CWP Rating: 175 psig.
 8. Maximum Operating Temperature: 200 deg F.

2.2 AIR VENTS

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Bell & Gossett; a Xylem brand
 - c. HCI; Hydronics Components Inc.
 - d. Nexus Valve, Inc.; Aalberts Hydronic Flow Control
 - e. Taco Comfort Solutions
 - f. WATTS; A Watts Water Technologies Company
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Bell & Gossett; a Xylem brand
 - c. Nexus Valve, Inc.; Aalberts Hydronic Flow Control
 - d. Spirotherm, Inc.
 - e. Taco Comfort Solutions
 - f. WATTS; A Watts Water Technologies Company
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

2.3 EXPANSION TANKS AND FITTINGS

A. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Armstrong Fluid Technology
 - c. Bell & Gossett; a Xylem brand
 - d. Taco Comfort Solutions

2. Tank: Welded steel, rated for 125 psig working pressure and 240 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Sight glass.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 AIR SEPARATORS

- A. Tangential-Type Air Separators:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Fluid Technology
 - b. Bell & Gossett; a Xylem brand
 - c. Spirotherm, Inc.
 - d. Taco Comfort Solutions
 2. Tank: Welded steel; ASME constructed and labeled for 125 psig minimum working pressure and 375 deg F maximum operating temperature.
 3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
 4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
 5. Blowdown Connection: Threaded.
 6. Size: Match system flow capacity.

2.5 BUFFER TANKS

- A. Vertical, floor-mounted ASME Chilled Water Buffer Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc. (CWBT-200)
 - b. Cemline Corporation (CWB-200)
 - c. Wessels Company (CBT-200)
 2. Tank: Welded carbon steel, rated for 125 psig working pressure at 400 degF maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with Section VIII of the ASME Code.
 3. Size: 200-gallon, 30-inch diameter, 60-to-72-inch height.
 4. Pipe Connections: Flanged or grooved end inlet and outlet, high side or front.
 5. Base: Ring support base
 6. Baffles: Internal baffle to properly circulate water flow.
 7. Insulation: 3/4" flexible elastomeric thermal insulation, black.
 8. Air Vent: 3/4 inch, top.
 9. Drain: 1 inch, bottom.

2.6 STRAINERS

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - b. Hays Fluid Controls
 - c. Nexus Valve, Inc.; Aalberts Hydronic Flow Control
 - d. Victaulic Company
 - e. WATTS; A Watts Water Technologies Company
 - f. Zurn Industries, LLC
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
4. Strainer Screen: Stainless steel, 20-mesh strainer, or perforated stainless steel basket.
5. CWP Rating: 125 psig.

2.7 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries
 - b. Flo Fab Inc
 - c. Metraflex Company (The)
2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

B. Spherical, Rubber, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries
 - b. Flo Fab Inc
 - c. Metraflex Company (The)
2. Body: Fiber-reinforced rubber body.
3. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
4. Performance: Capable of misalignment.
5. CWP Rating: 150 psig.
6. Maximum Operating Temperature: 250 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Examine threads on all devices for form and cleanliness.
- C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

- A. Install calibrated-orifice balancing valve at each branch connection to return main.
- B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.
- C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.
- C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- D. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.
- E. Install diaphragm- or bladder-type expansion tanks on the floor.
- F. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 23 2116

SECTION 23 2123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.
 - 2. Close-coupled, end-suction centrifugal pumps.
 - 3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
 - 4. Separately coupled, vertically mounted, in-line centrifugal pumps.
 - 5. Separately coupled, base-mounted, end-suction centrifugal pumps.

1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump.
 - 1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
 - 2. Indicate pump's operating point on curves.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Fluid Technology
 2. ITT Corporation
 3. Taco Comfort Solutions
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet and companion-flange connections.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 3. Pump Shaft Sleeve: Bronze.
 4. Pump Stub Shaft: Type 304 stainless steel.
 5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR or EPDM rubber bellows and gasket. Include water slinger on shaft between motor and seal.
 6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.
- D. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.
- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
1. Enclosure : Totally enclosed, fan cooled.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. Single-speed motor.
 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics: Refer to Schedules on Drawings.

2.3 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Fluid Technology
 2. ITT Corporation
 3. Taco Comfort Solutions

- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with drain plug at bottom and air vent at top of volute, threaded gauge tapings at inlet and outlet, and flanged connections.
 - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - 3. Pump Shaft Sleeve: Bronze.
 - 4. Pump Stub Shaft: Type 304 stainless steel.
 - 5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR or EPDM bellows and gasket. Include water slinger on shaft between motor and seal.
- D. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
 - 1. Enclosure: Totally enclosed, fan cooled.
 - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 5. Variable-speed motor.
 - 6. Provide integral pump motor variable-speed controller.
- E. Capacities and Characteristics: Refer to Schedules on Drawings.

2.4 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Fluid Technology
 - 2. ITT Corporation
 - 3. Taco Comfort Solutions
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gauge tapings at inlet and outlet, and threaded companion-flange connections.
 - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 - 3. Pump Shaft: Type 304 stainless steel or Type 316 stainless steel.

4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR or EPDM bellows and gasket.
 5. Pump Bearings: Permanently lubricated ball bearings.
- D. Shaft Coupling: Molded-rubber insert with interlocking spider capable of absorbing vibration.
- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
1. Enclosure Type: Totally enclosed, fan cooled.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. Single-speed motor.
 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics: Refer to Schedules on Drawings.

2.5 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Fluid Technology
 2. ITT Corporation
 3. Taco Comfort Solutions
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.
- C. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet and threaded companion-flange connections.
 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: Type 304 stainless steel or Type 316 stainless steel.
 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR or EPDM bellows and gasket.
- D. Shaft Coupling: Molded-rubber insert with interlocking spider capable of absorbing vibration.

- E. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
 - 1. Enclosure: Totally enclosed, fan cooled.
 - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 5. Single-speed motor.
 - 6. Provide integral pump motor variable-speed controller.
- F. Capacities and Characteristics: Refer to Schedules on Drawings.

2.6 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Fluid Technology
 - 2. ITT Corporation
 - 3. Taco Comfort Solutions
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump with flexible shaft coupling as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gauge tapplings at inlet and outlet, drain plug at bottom and air vent at top of volute, and flanged connections. Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring realignment of pump and motor shaft.
 - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps that are not frequency-drive controlled, trim impeller to match specified performance.
 - 3. Pump Shaft: Type 304 stainless steel or Type 316 stainless steel.
 - 4. Seal, Mechanical Type: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR or EPDM bellows and gasket.
 - 5. Seal, Packing Type: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 - 6. Pump Bearings: Permanently lubricated ball bearings.
- D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. EPDM coupling sleeve for variable-speed applications.

- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
 - 1. Enclosure: Totally enclosed, fan cooled.
 - 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 - 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 5. Variable-speed motor.
 - 6. Provide integral pump motor variable-speed controller.
- H. Capacities and Characteristics: Refer to Schedules on Drawings.

2.7 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:
 - 1. Angle pattern.
 - 2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
 - 3. Bronze 16-mesh wire startup and Type 304 stainless steel permanent strainers with 3/16-inch.
 - 4. Bronze or Type 304 stainless steel straightening vanes.
 - 5. Drain plug.
 - 6. Factory-fabricated support.
- B. Triple-Duty Valve:
 - 1. Angle or straight pattern.
 - 2. 175-psig pressure rating, cast-iron body, pump-discharge fitting.
 - 3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
 - 4. Brass valve disc with EPDM rubber seat.
 - 5. Type 304 stainless steel valve stem.
 - 6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
 - 7. Brass gauge ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support weight of in-line pumps.
 - 1. Comply with requirements for hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- C. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- D. Comply with pump and coupling manufacturers' written instructions.
- E. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, shutoff, and throttling valves or triple-duty valve on discharge side of pumps.

- E. Install Y-type strainer and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.
- H. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.

7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- B. Hydronic pumps will be considered defective if they do not pass tests and inspections.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 23 2123

SECTION 23 2513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Water treatment for closed-loop hydronic systems.
 - 2. Manual chemical-feed equipment.
 - 3. Automatic Glycol Make-up Units.
 - 4. Chemicals.
 - 5. Inhibited propylene glycol.

1.2 DEFINITIONS

- A. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.
- B. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 - 1. Bypass feeders.
 - 2. Automatic Glycol Make-up Units.
 - 3. Chemical-treatment test equipment.
 - 4. Chemical material safety data sheets.
 - 5. Inhibited propylene glycol.

1.4 INFORMATIONAL SUBMITTALS

- A. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- B. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT PROVIDERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Aqua-Chem, Inc.
 - 2. Cascade Water Services, Inc
 - 3. H-O-H Water Technology, Inc
 - 4. Nalco; an Ecolab company
 - 5. Watcon, Inc

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems shall have the following water qualities:
 - 1. pH: Maintain a value within 9.0 to 10.5.
 - 2. Alkalinity: Maintain a value between 100 to 500 ppm CaCO₃.
 - 3. TSS: Maintain a maximum value of 10ppm.
 - 4. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to 2.0 mils per year. Maintain soluble iron concentrations at or below 1.0 ppm.
 - 5. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to 0.3 mils per year. Maintain soluble copper concentrations at or below 0.2 ppm.
 - 6. Scale Control: Provide softened water for initial fill. Where softened water is not used for make-up, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.
 - 7. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
 - 8. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.

- b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
- c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
- d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
- e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Armstrong
 - 2. Neptune
 - 3. Griswald
 - 4. ITT Bell & Gossett
 - 5. Wessels Company
- B. Bypass Feeders: Provide steel feeders with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Provide quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - 1. Capacity: 2 gal.
 - 2. Minimum Working Pressure: 125 psig.

2.4 AUTOMATIC GLYCOL MAKE-UP UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Pumps Inc; GLA Series.
 - 2. ITT Bell & Gossett; GMU.
 - 3. John Wood Company; JWGP.
 - 4. Wessels Company; GMP.
- B. Description: Prefabricated, automatic and autonomous make-up package, pre-piped and pre-wired system, consisting of a chemical metering pump, tank, adjustable differential pressure switch, pressure gage, pressure relief valve, and control panel.
- C. Chemical Solution Tanks:
 - 1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
 - 2. Molded cover with recess for mounting pump.
 - 3. Support Frame: Welded steel.
 - 4. Capacity: 50 gal.
- D. Chemical Metering Pump: Positive displacement type with capacity adjustable through 100 percent of range by means of an easily accessible control. The pump shall be adjustable while running, and the pumped fluid shall not contact any metals of the drive assembly. Pump motor suitable for 115 volts/single-phase/60 hertz, with a minimum capacity of 1.5 GPH at 100 psig.

- E. Hand/Off/Auto Motor Starters: Mounted on skid for chemical metering pump.
- F. Control Panel: Furnished with the chemical tank assembly. Control panel shall be the master control center for all electrical equipment associated with the chemical tank assembly and shall include:
 - 1. Hand/Off/Auto Switch: For the chemical metering pump. The pump shall run continuously while the switch is in the HAND position.
 - 2. LED Indicator: For loss of pressure.
 - 3. Enclosure: NEMA 250 Type 4X, with all controls, switches, and indicating lights mounted on the front.
 - 4. Low Tank Level Interlock Alarm Circuit: To prevent the chemical pump from running dry. Circuit shall include pump lockout, tank level detector, visual alarm, audible alarm, and alarm silence button. Interlock circuit shall automatically reset when tank is refilled.
- G. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.

2.5 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, corrosion inhibitors, alkalinity, hardness, and other properties recommended by manufacturer.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. Two-station rack for closed-loop systems.

2.6 CHEMICALS

- A. Provide chemicals recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

2.7 INHIBITED PROPYLENE GLYCOL

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. CoreChem Inc.(Basis of Design Product: Gylcochill+ P200HD)
 - 2. Enerco
 - 3. The Dow Chemical Company
- B. Inhibited Propylene Glycol:
 - 1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon steel, brass, copper, stainless steel, and cast-iron piping and fittings.

2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. pH value shall be maintained between 9.0-10.0, with reserve alkalinity greater than 3.5 mL
4. Operating Temperature Range: Minus 50 deg F to 250 deg F.
5. Concentrated inhibited propylene glycol is to be 94.0 percent propylene glycol by weight and 6.0 percent performance additives.
6. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to minus 10 deg F. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
7. Provide only propylene glycol that meets ASTM D8039 Standard Specification for Heat Transfer Fluids (HTF) for Heating and Air Conditioning (HVAC) Systems. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Propylene Glycol manufacturer to perform an analysis of supply water to determine quality of water available at Project site.
- B. Water must meet or exceed the following Specification:
 1. Less than 50 ppm of calcium
 2. Less than 50 ppm of magnesium
 3. Less than 100 ppm (5 grains) of total hardness
 4. Less than 25 ppm of chloride
 5. Less than 25 ppm of sulfate
- C. If available water at site does not meet the above Specification, deionized water must be used for dilution.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
- B. Install water-testing equipment on wall near water-chemical-application equipment.
- C. Install interconnecting control wiring for chemical-treatment controls and sensors.
- D. Mount sensors and injectors in piping circuits.
- E. Bypass Feeders: Install in closed hydronic systems, including chilled water, and equip with the following:
 1. Install bypass feeder in a bypass circuit around circulating pumps unless indicated otherwise on Drawings.

2. Install water meter in makeup-water supply.
 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 5. Install a swing check on the inlet after the isolation valve.
- F. Install automatic fluid make-up equipment for glycol water system, and include the following:
1. Chemical solution tanks.
 2. Chemical solution injection pumps.
 3. Water meter in makeup supply to system.
 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 23 2113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 23 0523 "General-Duty Valves for HVAC Piping."
- E. Comply with requirements in Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.4 ELECTRICAL CONNECTIONS

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.

- B. Tests and Inspections:
1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 7. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. At six-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- F. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
 2. Acidity and Alkalinity: ASTM D1067.
 3. Iron: ASTM D1068.
 4. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.

6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 23 2513

SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.
- B. Related Requirements:
 - 1. Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Section 23 3300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- E. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
 - 3. Where specified for specific applications, all joints are to be welded.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.
 - 1. Where specified for specific applications, all joints are to be welded.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 304 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Elgen Manufacturing
 - 2. McGill AirFlow LLC

3. SEMCO, LLC; part of FlaktGroup
 4. Spiral Manufacturing Co., Inc.
- C. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.
- D. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- E. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- F. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- G. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
1. Galvanized Coating Designation: G90.
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

- D. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch- minimum diameter for lengths longer than 36 inches.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.
 4. Solids Content: Minimum 60 percent.
 5. Shore A Hardness: Minimum 60.
 6. Water resistant.
 7. Mold and mildew resistant.
 8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
 9. Service: Indoor or outdoor.
 10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

- E. Flanged Joint Sealant: Comply with ASTM C920.
 - 1. General: Single-component, acid-curing, silicone, elastomeric.
 - 2. Type: S.
 - 3. Grade: NS.
 - 4. Class: 25.
 - 5. Use: O.
- F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- G. Round Duct Joint O-Ring Seals:
 - 1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and is to be rated for 10-inch wg static-pressure class, positive or negative.
 - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- D. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 23 3300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class B.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

- 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 DUCTWORK CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 23 3300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Duct System Cleanliness Tests:
 - 1. Visually inspect duct system to ensure that no visible contaminants are present.
- C. Duct system will be considered defective if it does not pass tests and inspections.

3.7 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 6. Supply-air ducts, dampers, actuators, and turning vanes.
- C. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 2. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

3.8 STARTUP

- A. Air Balance: Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Supply Ducts:
1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
 2. Ducts Connected to Variable-Air-Volume Air-Handling Units:
 - a. Pressure Class: Positive 4-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- C. Return Ducts:
1. Ducts Connected to Fan Coil Units and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
 2. Ducts Connected to Variable-Air-Volume Air Handling Units:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 4.

- d. SMACNA Leakage Class for Round and Flat Oval: 4.
 - 3. Ducts Connected to Equipment Not Listed above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 2.
 - d. SMACNA Leakage Class for Round and Flat Oval: 2.
 - 2. Ducts Connected to Equipment Not Listed above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B if negative pressure; A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 1-inch wg.
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 8.
 - 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: C
 - c. SMACNA Leakage Class for Rectangular: 4.
 - d. SMACNA Leakage Class for Round and Flat Oval: 2.
 - 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 8.
 - d. SMACNA Leakage Class for Round and Flat Oval: 4.
- F. Intermediate Reinforcement:
 - 1. Galvanized-Steel Ducts: Galvanized steel.
- G. Elbow Configuration:
 - 1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

- 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
- 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct - Requirements for All Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.
- H. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.

- c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 23 3113

SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Barometric relief dampers.
 - 2. Manual volume dampers.
 - 3. Turning vanes.
 - 4. Duct-mounted access doors.
 - 5. Flexible connectors.
 - 6. Flexible duct connectors.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Construction details, material descriptions, and dimensions of individual components.

PART 2 - PRODUCTS

2.1 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. American Warming and Ventilating (AWV); Mestek, Inc.
 - 2. Greenheck Fan Corporation
 - 3. Nailor Industries Inc
 - 4. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
- B. General Requirements:
 - 1. Suitable for horizontal or vertical mounting.
 - 2. Maximum Air Velocity: 1250 fpm.
 - 3. Maximum System Pressure: 2 inches wg.
- C. Construction:
 - 1. Frame: Hat shaped, 16-gauge- thick, galvanized sheet steel or 0.063-inch- thick extruded aluminum, with welded corners or mechanically attached.
 - 2. Blades:
 - a. Multiple, 16-gauge- thick, galvanized sheet steel or 0.050-inch- thick aluminum sheet.
 - b. Maximum Width: 6 inches.
 - c. Action: Parallel.
 - d. Balance: Gravity.
 - e. End pivoted.
 - f. Seals: Neoprene.
 - g. Axles: Nonferrous metal.

3. Tie Bars and Brackets:
 - a. Material: Aluminum or Galvanized steel.
 - b. Rattle free with 90-degree stop.
 4. Bearings: Synthetic pivot bushings or steel ball bearing.
- D. Pressure Adjustment: Return spring or counter weight with adjustable tension.
- E. Accessories:
1. Flange on intake.
 2. Bird screen on intake or discharge.
 3. Adjustment device to permit setting for varying differential static pressures.

2.2 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Warming and Ventilating (AWV); Mestek, Inc.
 - b. Greenheck Fan Corporation
 - c. Nailor Industries Inc
 - d. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 2. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1 inch wg differential static pressure.
 3. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 4. Frames:
 - a. Hat-shaped, 16-gauge- thick, galvanized sheet steel or 18-gauge- thick stainless steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel; 16 gauge thick.
 6. Blade Axles: Galvanized steel.
 7. Bearings: Oil-impregnated bronze or Molded synthetic.
 - a. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
 8. Tie Bars and Brackets: Galvanized steel.
 9. Locking device to hold damper blades in a fixed position without vibration.
- B. Jackshaft:
1. Size: 0.5-inch diameter.
 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

- C. Damper Hardware:
 - 1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
 - 2. Include center hole to suit damper operating-rod size.
 - 3. Include elevated platform for insulated duct mounting.

2.3 TURNING VANES

- A. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Turning Vanes: Fabricate single-wall curved blades of galvanized steel.
 - 2. Acoustic Turning Vanes: Fabricate airfoil-shaped galvanized steel with perforated faces and fibrous-glass fill.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- C. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.4 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ductmate Industries, Inc; a DMI company
 - 2. Greenheck Fan Corporation
 - 3. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
- B. General Requirements: Fabricate access doors and pressure-relief doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
- C. Access Doors:
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Material matching duct material, with insulation fill matching duct insulation type and thickness, and access door wall thickness matching duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Material matching door material, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

- c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches.
- d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.5 DUCT FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ductmate Industries, Inc; a DMI company
 - 2. Duro Dyne Inc.
 - 3. DynAir; a Carlisle Company
- B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials are to have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
- C. Airstream Surfaces: Surfaces in contact with the airstream are to comply with requirements in ASHRAE 62.1.
- D. Materials: Flame-retardant or noncombustible fabrics.
- E. Coatings and Adhesives: Comply with UL 181, Class 1.
- F. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- G. Indoor System, Duct Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
 - 4. Service Temperature: Minus 50 to plus 250 deg F.
- H. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.6 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Galvanized Coating Designation: G60.
 2. Exposed-Surface Finish: Mill phosphatized.
- B. Aluminum Sheets: Comply with ASTM B209/B209M, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- C. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.
- D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.7 FLEXIBLE DUCTS, INSULATED

- A. Standard: Product is to be UL 181 listed and bearing the UL label.
- B. Flexible Ducts, Insulated - Class 1, Two-Ply Vinyl Film Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Flexmaster U.S.A., Inc
 - b. Thermaflex; a Flex-Tek Group company
 2. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 3. Maximum Air Velocity: 4000 fpm.
 4. Temperature Range: Minus 10 to plus 160 deg F.
 5. Insulation R-Value: Comply with ASHRAE/IES 90.1.
 6. Vapor-Barrier Film: Polyethylene or Aluminized, ASTM E96/E96M.
- C. Clamps: Stainless steel band with stainless steel or zinc-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR DUCT ACCESSORIES

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.

- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft and/or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having a duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream and downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links are to be pressure-relief access doors and be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50 ft. spacing.
 - 8. Upstream and downstream from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. For grease ducts, install at locations and spacing as required by NFPA 96.
 - 11. Control devices requiring inspection.
 - 12. Elsewhere as indicated.
- G. Install access doors with swing against duct static pressure.
- H. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.
- I. Label access doors in accordance with Section 23 0553 "Identification for HVAC Piping and Equipment" to indicate the purpose of each access door.

- J. Install flexible connectors to connect ducts to equipment.
- K. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- L. Install duct test holes where required for testing and balancing purposes.
- M. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.
- N. Install flexible ducts in accordance with applicable details in the following publications:
 - 1. ADC's "Flexible Duct Performance & Installation Standards" for flexible ducts.
 - 2. NAIMA AH116.
 - 3. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
 - 4. SMACNA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.
- O. Install in indoor applications only. Do not install flexible duct in locations where it will be exposed to UV rays.
- P. Where flexible duct is to be installed in locations where it will be exposed to UV rays, install only duct that is specifically made for this use and marked by the manufacturer.
- Q. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- R. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- S. Connect flexible ducts to metal ducts with draw bands.
- T. Installation of Flexible Ducts:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.
 - 3. Bends of flexible ducting must not exceed a minimum of one-duct diameter.
 - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - 5. Install flexible ducts in a direct line, without sags, twists, or turns.
 - 6. Install in accordance with ADC instructions.
- U. Supporting Flexible Ducts:
 - 1. Support flexible duct at manufacturer's recommended intervals, but at no greater distance than 4 ft. Provide sufficient support so that maximum centerline sag is 1/2 inch per ft. between supports. A connection to rigid duct or equipment may be considered a support joint.
 - 2. Install extra supports at bends placed approximately one-duct diameter from center line of the bend.

3. Ducts may rest on ceiling joists or truss supports. Spacing between supports must not exceed the maximum spacing in accordance with manufacturer's written installation instructions.
4. Vertically installed ducts must be stabilized by support straps at a maximum of 72 inches o.c.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. Operate dampers to verify full range of movement.
 2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
 4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 3300

SECTION 23 3400 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ventilators, centrifugal - ceiling mounted.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - b. Rated capacities, furnished specialties, and accessories for each fan.
 - c. Fans:
 - 1) Certified fan performance curves with system operating conditions indicated.
 - 2) Certified fan sound-power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5) Fan speed controllers.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fans and ventilators, include the following:
 - 1. Operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Capacities and Characteristics: Refer to equipment schedule on Drawings.

2.2 VENTILATORS, CENTRIFUGAL - CEILING MOUNTED

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Engineering & Manufacturing Corp.
 - 2. Broan.; a Broan-NuTone LLC brand; a Nortek company
 - 3. Greenheck Fan Corporation
 - 4. Loren Cook Company
 - 5. Panasonic Eco Solutions
 - 6. PennBarry; division of Air System Components
- B. Source Limitations: Obtain ceiling-mounted centrifugal ventilators from single manufacturer.
- C. Standards: Comply with UL 705.
- D. Housing: Steel, lined with acoustical insulation.
- E. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel are removable for service.
- F. Back-draft damper: Integral.
- G. Grille: Plastic or aluminum, louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.
- H. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

PART 3 - EXECUTION**3.1 INSTALLATION, GENERAL**

- A. Install fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Install units with adequate clearances for service and maintenance.
- E. Label fans in accordance with requirements specified in Section 23 0553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 3300 "Air Duct Accessories."

- B. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Description: Laminated acrylic or melamine plastic signs.
 - 2. Content: Black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

3.6 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
 - 3. Fans and components will be considered defective if they do not pass tests and inspections.

END OF SECTION 23 3400

SECTION 23 3600 - AIR TERMINAL UNITS (Bid Alternate #1)**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Modulating, single-duct air terminal units.
 - 2. Casing liner.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Price Industries Limited
 - 2. Titus; brand of Johnson Controls International plc, Global Products
 - 3. Trane
- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

- C. Casing: Minimum 20-gauge- thick galvanized steel.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for "Casing Liner, Flexible Elastomeric" Paragraph.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
- E. Velocity Sensors: Multipoint array with velocity inlet sensors.
- F. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.08 inch. Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- G. Direct Digital Controls:
 - 1. Terminal Unit Controller, Section 23 0923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 23 0923 "Direct Digital Controls (DDC) for HVAC."
- H. Control Sequence: See Section 23 0993.11 "Sequence of Operation for HVAC" for control sequences.

2.3 CASING LINER

- A. Casing Liner, Flexible Elastomeric: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 1. Minimum Thickness: minimum 1/2 inch.
 - 2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - 3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.4 SOURCE QUALITY CONTROL

- A. Water Coils: Factory pressure test to 300 psig in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION**3.1 INSTALLATION, GENERAL**

- A. Comply with Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" and Section 23 3113 "Metal Ducts" for hangers and supports.
- B. Install air terminal units according to NFPA 90A.
- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 PIPING CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Hot-Water Piping: Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties," and connect heating coils to supply piping with shutoff valve, strainer, control valve, and union or flange; and to return piping with balancing valve and union or flange.

3.3 DUCTWORK CONNECTIONS

- A. Comply with requirements in Section 23 3113 "Metal Ducts" for connecting ducts to air terminal units.
- B. Make connections to air terminal units with flexible connectors complying with requirements in Section 23 3300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.6 IDENTIFICATION

- A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows, and coil type. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

3.8 ADJUSTING

- A. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Air terminal unit will be considered defective if it does not pass tests and inspections.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 3600

SECTION 23 3713.13 - AIR DIFFUSERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Ceiling diffusers - rectangular and square face.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS**2.1 CEILING DIFFUSERS - RECTANGULAR AND SQUARE FACE**

- A. Ceiling Diffuser - Rectangular and Square:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products
 - b. METALAIRE, Inc
 - c. Price Industries Limited
 - d. Titus; brand of Johnson Controls International plc, Global Products
 - 2. Description: Square ceiling diffuser with round or rectangular duct collar and a series of curved louvers to provide discharge parallel to ceiling surface.
 - 3. Source Limitations: Obtain from single source from single manufacturer.
 - 4. Material: Steel.
 - 5. Finish: Baked enamel, white.
 - 6. Face Size: 24 by 24 inches.
 - 7. Face Style: Three cone.
 - 8. Mounting: T-bar.
 - 9. Pattern: Fixed.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers in accordance with ASHRAE 70.

PART 3 - EXECUTION**3.1 INSTALLATION OF AIR DIFFUSERS**

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713.13

SECTION 23 3713.23 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grilles - fixed-blade face.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - b. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 GRILLES

- A. Grilles - Fixed-Blade Face:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Krueger-HVAC; brand of Johnson Controls International plc, Global Products
 - b. METALAIRE, Inc
 - c. Price Industries Limited
 - d. Titus; brand of Johnson Controls International plc, Global Products
 - 2. Material: Steel.
 - 3. Finish: Baked enamel, color selected by Architect.
 - 4. Face-Blade Arrangement: Fixed-face blade position, horizontally spaced 1/2 inch apart.
 - 5. Core Construction: Integral.
 - 6. Frame: 1-1/4 inches wide.
 - 7. Mounting: Countersunk screw.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate registers and grilles in accordance with ASHRAE 70.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF REGISTERS AND GRILLES

- A. Install registers and grilles level and plumb.
- B. Outlets and Inlets Locations:
 - 1. Drawings indicate general arrangement of ducts, fittings, and accessories.
 - 2. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated.
 - 3. For units installed in lay-in ceiling panels, locate units in the center of panel.
 - 4. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713.23

SECTION 23 6423.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Air-cooled, scroll water chillers.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. DDC: Direct digital control.
- D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.
- E. GFI: Ground fault interrupt.
- F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- G. I/O: Input/output.
- H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.
- J. SCCR: Short-circuit current rating.
- K. TEAO: Totally enclosed air over.
- L. TENV: Totally enclosed nonventilating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Performance at AHRI standard conditions and at conditions indicated.
 - 3. Performance at AHRI standard unloading conditions.

4. Minimum evaporator flow rate.
 5. Refrigerant capacity of water chiller.
 6. Oil capacity of water chiller.
 7. Fluid capacity of evaporator.
 8. Characteristics of safety relief valves.
 9. Force and moment capacity of each piping connection.
- B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
1. Assembled unit dimensions.
 2. Weight and load distribution.
 3. Required clearances for maintenance and operation.
 4. Size and location of piping and wiring connections.
 5. Diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Certificates: For certification required in "Quality Assurance" Article.
- B. Installation instructions.
- C. Startup service reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
 2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit" with text size at least 1 inch high.
 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size is to be at least 1/2 inch high.

- B. Touchup Paint: 32 oz. container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.7 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

1.9 WARRANTY

- A. Manufacturers agree to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller including refrigerant and oil charge, including parts and labor: One year after start-up.
 - b. Complete compressor and drive assembly, parts only: 5 years after start-up.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.
- B. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- D. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- E. Comply with NFPA 70.
- F. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- G. Operation Following Loss of Normal Power:
 - 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system is to automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.

2. See drawings for equipment served by backup power systems.
 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- H. Outdoor Installations:
1. Chiller is to be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
 2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.
- I. Chiller shall be capable of starting and running at outdoor ambient temperatures from 32°F (0°C) to 115°F (46°C).
- J. Chiller shall be capable of starting up with 95°F (35°C) entering fluid temperature to the evaporator. Maximum water temperature that can be circulated with the Chiller not operating is 125°F (52°C).
- K. Chiller shall provide evaporator freeze protection and low limit control to avoid low evaporator refrigerant temperature trip-outs during critical periods of chiller operation. Whenever this control is in effect, the controller shall indicate that the chiller is in adaptive limit. If the condition exists for more than 30 seconds, a limit warning alarm relay shall energize.

2.2 AIR-COOLED, SCROLL WATER CHILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Daikin Applied
 2. Trane (Models ACSA 160-ton and CGAM 110-ton used as basis of design)
 3. YORK; brand of Johnson Controls International plc, Building Solutions North America
- B. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.
- C. Sound-reduction package is to have the following:
1. Acoustic enclosure around compressors.
 2. Reduced-speed fans with acoustic treatment.
 3. Designed to reduce sound level without affecting performance.
 4. Acoustics: Manufacturer must provide both sound power and sound pressure data in decibels, per AHRI 370. A-weighted sound pressure at 30 feet should be provided at 100%, 75%, 50% and 25% load points to identify the full operational noise envelope.

D. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
3. Casing: Galvanized steel.
4. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B117.
5. Control panel doors shall have door stays.
6. Mount starters and Terminal Blocks in a UL 60335-2-40 rated weatherproof panel provided with full opening access doors. If a circuit breaker is chosen, it should be a lockable, through-the-door type with an operating handle and clearly visible from outside of chiller indicating if power is on or off.

E. Compressor-Drive Assemblies:

1. Compressors:
 - a. Description: Positive-displacement direct drive with hermetically sealed casing.
 - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 - c. Capacity Control: On-off compressor cycling.
 - 1) Each compressor shall have Intermediate Discharge Valves (IDV) or variable volume ratio technology.
 - d. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.
 - 1) Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
 - e. Vibration Isolation: Mount individual compressors on vibration isolators.
 - 1) For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
2. Compressor Motors:
 - a. Hermetically sealed and cooled by refrigerant suction gas.
 - b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
3. Compressor Motor Controllers:
 - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

F. Refrigeration System:

1. Refrigerant: R-454B, ASHRAE 34 Safety Group A2L.
2. Refrigerant Compatibility: Parts exposed to refrigerants are to be fully compatible with refrigerants, and pressure components are to be rated for refrigerant pressures.

3. Refrigerant Circuit: Each circuit is to include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 4. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.
 5. Pressure Relief Device:
 - a. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
 - c. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) is to be provided for each heat exchanger.
- G. Evaporator:
1. Braze plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material:
 - a. Direct-expansion, single-pass, brazed-plate design.
 - b. Fluid Nozzles: Terminate with grooved-end connections for connection to field piping.
 2. Flow Switch: Factory-furnished and -installed flow switch wired to chiller operating controls.
 3. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F.
- H. Air-Cooled Condenser:
1. Coil(s) with integral subcooling on each circuit.
 2. Construct condenser coils of all Long Life Alloy aluminum brazed fin constructions. The condenser coils shall be designed for at least 650 psig working pressure. Leak tested at 650 psig . Coils can be cleaned with high pressure water.
 3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
 4. Fans: Low-Sound variable-speed direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
 5. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
 6. Fan Guards: Removable steel safety guards with corrosion-resistant coating.
- I. Chilled-Water Hydronic Package:
1. Factory-furnished and -installed hydronic package consisting of the following:
 - a. Pumps: Dual pumps with capacity, as indicated.
 - 1) Serviceable without disturbing piping connections.
 - 2) Cast-iron, ductile-iron, bronze, or stainless-steel body.

- 3) Bronze or stainless-steel impeller keyed to shaft and secured with screw.
- 4) Premium efficient motor with TEFC motor enclosure.
- 5) Dual pump packages to provide for servicing and replacement of failed pump with other pump operating.
- 6) Variable-speed pumps with variable-frequency controllers provided with chiller electrical package.
- 7) VFDs installed in an additional panel to control the pumps. VFDs to accept a signal from a BAS for variable primary flow.
- 8) VFD to be adjusted upon start up to balance the system flow and head requirements. The purpose is to save on wasted pump energy caused by a traditional balancing valve.
- 9) Include single point power integrated into the chiller unit power with a separate factory wired control panel.
- b. Expansion Tank: 6-gallon, factory installed. (available on Trane CGA model only)
- c. Storage (Buffer) Tank: 195-gallon insulated carbon-steel tank with internal baffles, drain and vent connections; factory installed. (available on Trane CGA model only)
- d. Piping: Copper tube or carbon-steel pipe.
- e. Strainers: Y-type at suction side of each pump.
- f. Valves:
 - 1) Ball- or butterfly-style valves for isolation and balancing.
 - 2) Check valve on each pump discharge for dual pump packages.
 - 3) Drain valves to be positioned to drain isolated sections of pipe and equipment.
 - 4) Option to use combination valves.
- g. Hydronic Specialties:
 - 1) Air Vents: Automatic or manual air vents located and arranged to vent air from high points and locations capable of trapping air.
 - 2) Test Plugs: Located to measure pressure difference across each pump and strainer.
2. Hydronic package rated for same pressure as evaporator.
3. Pressure and leak tested before applying insulation.
4. Insulation on hydronic package is to match evaporator insulation.
5. Controls: The control of the pump is integrated into the chiller controller.
 - a. The chiller controls both pumps through a lead/lag and failure/recovery functionality.
 - b. The controller displays both of the evaporator pump starts and run-times.
 - c. Freeze protection down to an ambient of -20°F.
 - d. Lead/lag operation for dual pump packages.
 - e. Controlled to automatically equalize run time.
 - f. Control of variable-speed pumps.
 - g. Integral to chiller control package.

J. Insulation:

1. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components are to include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, hydronic pump package and auxiliary piping.
 - a. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
 - b. Field-Applied Insulation:
 - 1) Components that are not factory insulated are to be field insulated to comply with manufacturer requirements.
 - 2) Manufacturer is to be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
 - 3) Manufacturer's factory-authorized service representative is to instruct and supervise installation of field-applied insulation.
 - 4) After field-applied insulation is complete, paint insulation to match factory-applied finish.

K. Electrical:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary are to provide a single-point field power connection to water chiller.
3. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
4. Wiring is to be numbered and color-coded to match wiring diagram.
5. Factory wiring is to be located outside of an enclosure in a raceway. Make terminal connections with not more than a 24-inch length of liquid tight conduit.
6. Field power interface is to be to NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.
7. Each motor is to have branch power circuit and controls having SCCR to match main disconnecting means.
8. Each motor is to have overcurrent protection.
9. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
10. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
11. Power Factor Correction: Capacitors to correct power factor to 0.90 at full load.
12. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
13. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.
14. Indicate the following for water chiller electrical power supply:
 - a. Current, phase to phase, for all three phases.
 - b. Voltage, phase to phase and phase to neutral for all three phases.
 - c. Three-phase real power (kilowatts).
 - d. Three-phase reactive power (kilovolt amperes reactive).

- e. Power factor.
 - f. Running log of total power versus time (kilowatt hours).
 - g. Fault log, with time and date of each.
- L. Controls:
- 1. Factory installed and wired, and functionally tested at factory before shipment.
 - 2. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
 - 3. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
 - 4. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:
 - a. Date and time.
 - b. Operating or alarm status.
 - c. Operating hours.
 - d. Outside-air temperature if required for chilled-water reset.
 - e. Temperature and pressure of operating set points.
 - f. Chilled-water entering and leaving temperatures.
 - g. Refrigerant pressures in evaporator and condenser.
 - h. Saturation temperature in evaporator and condenser.
 - i. No cooling load condition.
 - j. Elapsed time meter (compressor run status).
 - k. Pump status.
 - l. Antirecycling timer status.
 - m. Percent of maximum motor amperage.
 - n. Current-limit set point.
 - o. Number of compressor starts.
 - p. Alarm history with retention of operational data before unit shutdown.
 - 5. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Capacity control based on evaporator leaving-fluid temperature.
 - c. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
 - d. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Reset chilled-water leaving temperature based on return-water or outside-air temperature.
 - e. Current limit and demand limit.
 - f. Condenser-water temperature.
 - g. External water chiller emergency stop.
 - h. Solid-state 5 minute antirecycling timer.
 - i. Automatic lead-lag switching.
 - 6. Manual-Reset Safety Controls: The following conditions are to shut down water chiller and require manual reset:
 - a. Low evaporator pressure or high condenser pressure.
 - b. Low chilled-water temperature.
 - c. Refrigerant high pressure.
 - d. High or low oil pressure.
 - e. High oil temperature.
 - f. Loss of chilled-water flow.
 - g. Loss of condenser-water flow.

- h. Control device failure.
 - i. Motor current overload.
 - j. Phase reversal/unbalance/single phase.
 - k. Under/over voltage.
 - l. Failure of water temperature sensor.
- 7. BAS or DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.
 - a. Communication Interface: ASHRAE 135 (BACnet) communication interface is to enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel is to be available through DDC system for HVAC.
- M. Accessories:
 - 1. Factory-furnished neoprene isolators for field installation.
- N. Capacities and Characteristics (**CH-1: Trane ACSA-160**):
 - 1. Nominal Capacity: 160 tons.
 - 2. Operating Capacity: 136.9 tons.
 - 3. Superior Sound Package.
 - 4. Full-Load Efficiency:
 - a. EER: 10.04.
 - 5. Part-Load Efficiency:
 - a. IPLV: 17.70.
 - b. NPLV: 15.84.
 - 6. Low Ambient Operation: Chiller designed for operation to minus 20 deg F.
 - 7. High Ambient Operation: Chiller designed for operation to 115 deg F.
 - 8. Evaporator:
 - a. Type: Brazed plate.
 - b. Pressure Rating (water side): 150 psig.
 - c. Pressure Rating (refrigerant side): 650 psig.
 - d. Fluid Type: 30% Propylene Glycol.
 - e. Design Fluid Flow Rate: 247.7 gpm.
 - f. Minimum Fluid Flow Rate: 203.5 gpm.
 - g. Entering-Fluid Temperature: 56.0 deg F.
 - h. Leaving-Fluid Temperature: 42.0 deg F.
 - i. Fluid Pressure Drop: 7.35 feet of head.
 - j. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.
 - k. Water Storage: 17.3 gallons (does not include pump package).
 - 9. Condenser Entering-Air Temperature: 95 deg F.
 - 10. Number of Condenser Fans: 8.
 - 11. Site Altitude: 600 feet .
 - 12. Number of Refrigeration Circuits: Two.
 - 13. Hydronic Package:
 - a. Number of Pumps: Two.
 - b. Pump Control: Variable speed.
 - c. Pump Available Head Pressure: 104.9 ft H₂O.
 - d. Pump Speed: 3500 rpm.
 - e. Pump Motor Horsepower: 25.
 - f. Expansion Tank: not included.

- g. Storage Tank: not included.
 - 14. Number of Compressors: 4
 - 15. Compressor Rated Load Amperes: 69.0 / 69.0 / 69.0 / 69.0.
 - 16. Compressor Locked-Rotor Amperes: 389 / 389 / 389 / 389.
 - 17. Controls Power Connection: Fed through integral transformer.
 - 18. Chiller Power Input: 163.7 kW.
 - 19. Chiller Minimum Circuit Ampacity: 347 A.
 - 20. Chiller Maximum Overcurrent Protection Device: 400 A.
 - 21. Chiller Electrical Characteristics: 480-V ac, three phase, 60 Hz.
- O. Capacities and Characteristics (**CH-2: Trane CGAM-110 High Efficiency**):
- 1. Nominal Capacity: 110 tons.
 - 2. Operating Capacity: 101.9 tons.
 - 3. Comprehensive Sound Package.
 - 4. Full-Load Efficiency:
 - a. EER: 9.62.
 - 5. Part-Load Efficiency:
 - a. IPLV: 16.06.
 - b. NPLV: 14.79.
 - 6. Low Ambient Operation: Chiller designed for operation to minus 20 deg F.
 - 7. High Ambient Operation: Chiller designed for operation to 115 deg F.
 - 8. Evaporator:
 - a. Type: Brazed plate.
 - b. Pressure Rating (water side): 150 psig.
 - c. Pressure Rating (refrigerant side): 460 psig.
 - d. Fluid Type: 30% Propylene Glycol.
 - e. Design Fluid Flow Rate: 184.3 gpm.
 - f. Minimum Fluid Flow Rate: 149.0 gpm.
 - g. Entering-Fluid Temperature: 56.0 deg F.
 - h. Leaving-Fluid Temperature: 42.0 deg F.
 - i. Fluid Pressure Drop: 8.01 feet of head.
 - j. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu.
 - k. Water Storage: 10.3 gallons (does not include pump package).
 - 9. Condenser Entering-Air Temperature: 95 deg F.
 - 10. Number of Condenser Fans: 8.
 - 11. Site Altitude: 600 feet .
 - 12. Number of Refrigeration Circuits: Two.
 - 13. Hydronic Package:
 - a. Number of Pumps: Two.
 - b. Pump Control: Variable speed.
 - c. Pump Available Head Pressure: 91.4 ft H₂O.
 - d. Pump Speed: 3500 rpm.
 - e. Pump Motor Horsepower: 10.
 - f. Expansion Tank: 6 gallon.
 - g. Storage Tank: 195 gallons.
 - h. Number of Compressors: 4.
 - 14. Compressor Rated Load Amperes: 41.9 / 50.6 / 50.6 / 41.9.
 - 15. Compressor Locked-Rotor Amperes: 260 / 320 / 320 / 260.
 - 16. Controls Power Connection: Fed through integral transformer.
 - 17. Chiller Power Input: 127 kW.

18. Chiller Minimum Circuit Ampacity: 238 A.
19. Chiller Maximum Overcurrent Protection Device: 300 A.
20. Chiller Electrical Characteristics: 480-V ac, three phase, 60 Hz.

P. Materials:

1. Steel:
 - a. ASTM A36/A36M for carbon structural steel.
 - b. ASTM A568/A568M for steel sheet.
2. Stainless Steel:
 - a. Manufacturer's standard grade for casing.
 - b. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
3. Galvanized Steel: ASTM A653/A653M.
4. Aluminum: ASTM B209.

Q. Source Quality Control:

1. Perform functional test of water chillers before shipping.
2. Factory performance test water chillers, before shipping, according to AHRI 550/590.
 - a. Test the following conditions:
 - 1) Design conditions indicated.
 - 2) AHRI 550/590 part-load points.
3. Factory test and inspect evaporator according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
4. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF AIR-COOLED, SCROLL WATER CHILLERS

- A. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.
- B. Equipment Mounting:
 1. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- C. Maintain manufacturer's recommended clearances for service and maintenance.

- D. Maintain clearances required by governing code.
- E. Chiller manufacturer's factory-trained service personnel are to charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- F. Install separate devices furnished by manufacturer and not factory installed.
 - 1. Chillers shipped in multiple major assemblies are to be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

- A. Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to chillers, allow space for service and maintenance.
- C. Chiller Fluid Connections:
 - 1. Connect to inlet and outlet with flexible connector and drain connection with valve.
 - 2. Make connections to water chiller with a flange or mechanical coupling.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 1/2 inch high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
- C. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate is to be laminated phenolic layers of black with engraved white letters at least 1/2 inch high.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 2. Verify that pumps are installed and functional.
 - 3. Verify that thermometers and gages are installed.
 - 4. Operate water chiller for run-in period.
 - 5. Check bearing lubrication and oil levels.
 - 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 - 7. Verify proper motor rotation.
 - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 - 9. Verify and record performance of chilled-water flow and low-temperature interlocks.
 - 10. Verify and record performance of water chiller protection devices.
 - 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- E. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.
 - 1. Instructor is to be factory trained and certified.
 - 2. Provide not less than eight hours of training.
 - 3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
 - 4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 5. Obtain Owner sign-off that training is complete.
 - 6. Hold Owner training at Project site.

END OF SECTION 23 6423.13

SECTION 23 7313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Indoor, semi-custom air-handling unit sections. New Supply Fan Module and Chilled Water Coil Module for existing AHU-5B: York Solution Indoor Air Handler 60 x 96; Model Number XTI-060X096-FALA046A, Serial Number CLPMXT0065).
 - a. Supply fan (replacement supply fan module for existing York air handling unit; existing unit length is 58").
 - b. Hydronic air coil (new chilled water coil module to add to existing York air handling unit).
 - c. Contractor shall field measure and verify existing air handling unit dimensions for installation of modules prior to generating submittals.

1.2 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - 6. Include certified coil-performance ratings with system operating conditions indicated. Product data to include dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
- B. Shop Drawings: For each type and configuration required for new AHU-5B supply fan section and chilled water coil sections.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of attaching new sections to existing AHU-5B, as well as procedures and diagrams.
 - 4. Include diagrams for power, signal, and control wiring.
 - 5. Details of casing connections to field-installed ductwork.

1.3 INFORMATIONAL SUBMITTALS

- A. Startup service reports.
- B. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of new air-handling unit sections/modules that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Structural Performance: Casing panels are to be self-supporting and capable of withstanding positive/negative 8-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch of panel span.
- F. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8 inch wg.
- G. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.
 - 1. Unit Life Expectancy: 25 years.
 - 2. Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.

2.2 CAPACITIES AND CHARACTERISTICS

- A. See equipment schedules on Drawings.

2.3 INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS (NEW AHU-5B SECTIONS)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. YORK; brand of Johnson Controls International plc, Building Solutions North America
- B. Unit Casings:
1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
 2. Mounting Requirements: Units mounted on concrete housekeeping pads.
 3. Base Rail:
 - a. Material: Galvanized steel.
 - b. Height: Match existing 6".
 4. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
 5. Double-Wall Construction:
 - a. Outside Casing Wall:
 - 1) Material, Galvanized Steel: Minimum 18 gauge thick.
 - 2) Factory Finish: Provide manufacturer's standard finish.
 - b. Inside Casing Wall:
 - 1) Material, Galvanized Steel: Solid for Coil Section, Perforated for Fan Section, minimum 18 gauge thick.
 6. Floor Plate:
 - a. Material, Galvanized Steel: Treadplate, minimum 16 gauge thick.
 7. Casing Insulation:
 - a. Materials: Glass-fiber insulation layered over injected foam in perforated interior casing sections to meet specified acoustic requirements.
 - b. Casing Panel R-Value: Minimum R-13.
 - c. Insulation Thickness: match existing.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
 8. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.
 9. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
 10. Static-Pressure Classifications:
 - a. For Unit Sections Downstream and Including Fans: 4-inch wg.
 11. Panels, Doors, and Windows:
 - a. Doors:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.

- 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. Retain "Windows" Subparagraph below to add windows in access panels and doors.
 - b. Windows:
 - 1) Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
 - 2) Size: Minimum 6 inches, square or round.
 - c. Locations and Applications:
 - 1) Fan Section: Doors, with windows.
- C. Centrifugal Plenum Fans:
 - 1. Operating Performance:
 - a. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - 1) Add additional static pressure to fan scheduled total static pressure.
 - 2) If fan motor horsepower is increased, notify Architect.
 - b. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 - c. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 - d. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 - e. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 - f. As a minimum, fans shall have AMCA class indicated on Drawings.
 - 1) If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - 2) AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 - g. Motor starting torque shall exceed fan speed-torque requirements.
 - 2. Vibration Balance:
 - a. Each fan/motor assembly shall be factory balanced to AMCA 204 through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be 20 percent of design speed.
 - b. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 - c. Submit test reports as an information submittal for Project record.

3. Operation and Service Requirements:
 - a. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 - b. Design and incorporate features to permit safe, rapid, and economical maintenance.
4. Fan Base:
 - a. Mount fan, motor, and drive on a structural-steel base.
 - b. Include base and vibration isolators in accordance with requirements indicated.
 - c. Electrically weld the base.
 - d. Size and design the base construction to withstand the rigors of shipping and rigging.
 - e. Include the base with lifting lugs or holes.
 - f. Construct base with gusseted brackets to accommodate spring isolators.
5. Fan Panel:
 - a. Construct fan panel of aluminum or powder-coated steel.
 - b. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 - c. Reinforce and brace fan panel to prevent vibration and pulsation.
 - d. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
6. Fan Inlet and Wheel Cone:
 - a. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 - b. Inlet and wheel cones shall be hyperbolic.
 - c. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 - d. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
 - e. Inlet cones that are held in place using retaining clips are unacceptable.
7. Fan Wheel:
 - a. Fan blades shall be a true hollow airfoil shape, continuously welded to backplate and wheel cone.
 - b. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 - c. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 - d. Construct fan hubs of cast aluminum or cast iron, ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.
 - e. Statically and dynamically balance fan wheel before fan is assembled.
8. Fan Drive:
 - a. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
 - b. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
 - c. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
 - d. Construct motor base and pedestal of aluminum or powder-coated carbon steel plate.

- e. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.
 - 9. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.
 - a. Expanded metal or welded wire welded to a painted carbon steel or stainless steel frame.
 - b. Screens shall comply with OSHA requirements.
 - c. Screens shall be constructed of painted carbon or stainless steel.
 - d. Fasten screens to fan frame for easy removal by maintenance personnel.
 - 10. Welding:
 - a. Use AWS- or ASME-certified welders to weld materials required by application.
 - b. All welds shall be continuous full-penetration welds.
 - 11. Hardware: Hex-head, high-strength carbon steel or 300 series stainless steel.
 - 12. Nameplates:
 - a. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 - b. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 - c. Locate nameplates in a highly visible location on motor side of fan.
 - 13. Air-Handling Unit Factory Assembly:
 - a. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - b. Fan Supports:
 - 1) Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - 2) Construct frame work from aluminum, galvanized steel, or stainless steel.
- D. Hydronic Coils:
- 1. Design and Performance:
 - a. Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.
 - b. Design coils to be drainable.
 - 1) Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - c. Design coils to be self-venting.
 - d. Coils supply and return piping connections on same end of coil.
 - e. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than 200 psig.
 - f. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - 1) Face Velocity: Maximum of 550 fpm.
 - 2) Fluid Tube Velocity (at Design Flow Rate):
 - a) Maximum: 6 fps.
 - b) Minimum: 3 fps.

- 3) Fin Spacing: Maximum 12 fins per inch, or spacing required to meeting required capacities without exceeding allowable air pressure drop at design airflow.
 - g. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
2. Fins:
 - a. Materials:
 - 1) Aluminum: 0.0060 inch thick.
 - b. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 - c. Fin Configuration: Flat face fins without ripples.
3. Headers:
 - a. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 - b. Drains: Include low point of supply and return header with a NPS 1/2 drain connection. Extend copper pipe through air-handling unit casing and terminate end with male national pipe thread (MNPT). Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - c. Vents: Include high point of supply and return header with a NPS 1/2 vent connection. Extend copper pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 - d. Supply and Return Connections:
 - 1) Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or carbon steel pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - 2) Connections NPS 2-1/2 and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 - e. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
4. Tubes:
 - a. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
 - b. Tube Nominal Diameter: 1/2 or 5/8 inch before expanding, selected to provide performance indicated.
 - c. Tube Nominal Wall Thickness: As required by performance, minimum of 0.020 inch thick.
5. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
 - a. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of 0.020 inch thick.
6. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.

7. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.
8. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - a. Manufacturer name, address, telephone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Coil fin length.
 - f. Coil fin height.
 - g. Coil weight with fluid/without fluid.
 - h. Coil casing material and thickness.
 - i. Coil fin material and thickness.
 - j. Coil tube material and thickness.
9. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
10. Air-Handling Unit Factory Assembly:
 - a. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately 4 inches beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
 - b. Internal Access: Include each coil with internal access from downstream sides.
 - c. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 - d. Supports for Coils:
 - 1) Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - 2) Construct framework for cooling coils, from aluminum or stainless steel structural shapes.

2.4 MATERIALS

- A. Steel:
 1. ASTM A36/A36M for carbon structural steel.
 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 1. Manufacturer's standard grade for casing.
 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B 09.

2.5 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- C. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- D. Water Coils: Factory tested to 300 psig in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

- D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Chilled-Water Piping: Comply with applicable requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Comb coil fins for parallel orientation.
- B. Starting procedures for air-handling units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
 - 2. Measure and record motor electrical values for voltage and amperage.

3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.7 ADJUSTING

- A. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks.
 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 7313.16

SECTION 23 8216.11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hydronic air coils (new chilled water coils to replace existing DX coils in existing York air handling units).
 - a. Contractor shall field measure and verify available interior dimensions for installation of new coils prior to generating coil submittals.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air coils to be included in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."
- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: 200 psig/300 deg F.
- D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.
- E. Chilled-Water Coil Capacities and Characteristics: Refer to coil schedule on Drawings.

2.2 HYDRONIC AIR COILS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Trane

2. USA Coil & Air
 3. York
- B. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.
- C. Tubes:
1. Material: Copper.
 2. Nominal Diameter: 1/2 inch or 5/8 inch before expanding, selected to provide performance indicated.
 3. Nominal Wall Thickness: As required by performance.
 4. Return Bends: 180-degree bends; material and nominal diameter to match tubes.
 5. Features: Individually drainable.
- D. Fins:
1. Type: Plate.
 2. Materials:
 - a. Aluminum: 0.0060 inch (0.15 mm) thick.
 3. Spacing: Maximum 12 fins per inch, or spacing required to meeting required capacities without exceeding allowable air pressure drop at design airflow.
 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 5. Configuration: Fin type as required by performance requirements.
 6. Fin and Tube Joint: Mechanical bond.
- E. Headers:
1. Material: Copper.
 2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
 3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
 4. Drains: Include low point of supply header with drain connection.
 5. Vents: Include high point of return header with vent connection.
 6. Supply and Return Connections: Copper pipe; threaded or flanged, same end of coil.
 7. Protection: Protect supply, return, vent, and drain opening connections with a threaded cap to prevent entry of dirt into coil.
 8. Fluid Velocity at Design Flow Rate: Refer to cooling coil schedule on Drawings.
- F. Casings and Tube Sheets:
1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving sides.
 2. Materials:
 - a. Stainless steel, Type 304, No. 2D finish, ASTM A240/A240M.

- G. Top and Bottom Casings:
 - 1. Flange face minimum of 1-1/2 inches; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
 - 2. Thickness:
 - a. Coils with Fin Length of Up to 72 Inches: Minimum of 16 gauge thick.
 - b. Coils with Fin Length Exceeding 72 Inches: Minimum of 12 gauge thick.
- H. End Tube Sheets:
 - 1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - 2. Flange face minimum of 1 inch.
 - 3. Thickness: Match casing dimensions.
- I. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
- J. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 or Type 316 stainless steel.
- K. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
 - 1. Manufacturer name, address, telephone number, and website address.
 - 2. Manufacturer model number.
 - 3. Serial number.
 - 4. Manufacturing date.
 - 5. Coil identification (as indicated on Drawings).
 - 6. Coil fin length.
 - 7. Coil fin height.
 - 8. Coil weight with fluid/without fluid.
 - 9. Coil casing material and thickness.
 - 10. Coil fin material and thickness.
 - 11. Coil tube material and thickness.
 - 12. Coil header material and thickness.

2.3 MATERIALS

- A. Aluminum: ASTM B209.
- B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.
- C. Copper Sheet: ASTM B152.
- D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.
- E. Steel:
 - 1. Pipe Connections: ASTM A53/A53M.

2.4 SOURCE QUALITY CONTROL

- A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.
 - 1. Include display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine ducts, plenums, and casings indicated to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Maintain existing or install new galvanized-steel drain pan under each cooling coil.
 - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 - 3. Extend drain pan upstream and downstream from coil face.
 - 4. Extend drain pan under coil headers and exposed supply piping.
- C. Straighten bent fins on air coils.
- D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 23 0923.11 "Control Valves," and other piping specialties are specified in Section 23 2116 "Hydronic Piping Specialties."

END OF SECTION 23 8216.11

SECTION 26 0000 - GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Drawings and specifications.
 - 2. Scope of work.
 - 3. Codes, permits and inspections.
 - 4. Interferences.
 - 5. Materials and workmanship.
 - 6. Acceptance.

1.2 DRAWINGS AND SPECIFICATIONS

- A. The Architectural, Structural, Mechanical, Electrical, and equipment drawings and specifications are hereby incorporated into and become a part of this Division. Contractor shall examine all such drawings and specifications and become thoroughly familiar with provisions contained herein and the submission of his bid shall be construed as indicating such knowledge. All drawings and specifications will be available according to Instructions to Bidders.
- B. Electrical drawings are in part diagrammatic, intending to convey scope of work, indicating general arrangement of panelboards, switches, equipment, conduit, outlets, and other devices. Due to the diagrammatic nature of the drawings, many of the necessary individual component parts are not indicated but shall be included by the Contractor for a complete and operable electrical system. Follow drawings in laying out work, and verify places for installation of materials and equipment. Whenever a question exists as to exact intended location of outlets or equipment, obtain instructions from the Engineer before proceeding with work. Information presented on these drawings is as accurate as preliminary surveys and planning can determine, but complete accuracy is not guaranteed, and Contractor field verification of all dimensions and conditions is required.
- C. All changes from these drawings necessary to make the work conform to the building as constructed and to fit the work of other trades or to conform to the rules and regulations of the State, City, or Municipal bodies having jurisdiction, are to be made by electrical contractor, at his own expense.

- D. The exact locations of apparatuses, fixtures, equipment and conduits shall be ascertained from the Owner or his representative in the field, and the work shall be laid out accordingly. Should the Contractor fail to ascertain such locations, the work shall be changed at his own expense when so ordered by the Owner. The Owner reserves the right to make minor changes in the location of conduit and equipment up to the time of installation, without additional cost.
 - 1. Unless otherwise indicated, within industrial buildings, all conduit, cable tray and busway shall be routed at the elevation of the roof framing except where individual drops are made to distribution equipment, utilization equipment, fixtures or devices.
- E. The electrical drawings and specifications are intended to supplement each other, and any material or labor called for in one shall be supplied even though not specifically mentioned in both. Labor and/or materials neither shown nor specified, but necessary for the completion and proper functioning of the system, shall be provided by Contractor.
- F. Should conflicting information exist in the drawings and/or specifications, the better quality or greater quantity shall be provided when a clarification cannot be obtained.

1.3 SCOPE OF WORK

- A. Supply all labor and material to complete all electrical work shown on the drawings, specified herein or required to complete the construction of the building as shown.
- B. The listing of article or material, operation or method, requires that the Contractor shall provide and install, unless noted to be supplied by others, each item listed of quality or subject to qualification noted. Each operation shall be performed according to standard practice, manufacturer's instructions and conditions stated, providing all necessary labor, equipment and incidentals.
- C. The principal items of work include but are not limited to the following:
 - 1. Electrical demolition work as indicated or required.
 - 2. Complete electrical service modifications at facility.
 - 3. Complete branch circuit wiring system.
 - 4. Complete interior lighting system as indicated.
 - 5. Testing of all electrical equipment and each system.
 - 6. Wiring of mechanical equipment.
- D. Responsibility: the electrical contractor shall be responsible for the work of all his sub-contractors and the materials of all his suppliers. Include all materials, labor, and equipment required for a complete and working installation. Do not supply materials that will not work in the particular situation of this project.

1.4 CODES, PERMITS AND INSPECTIONS

- A. Install all work in full accord with codes, rules and regulations of Municipal, City, County, State and Public Utilities and all other authorities having jurisdiction over the premises. This shall include all requirements of the City Building Code, regulations of the State Department of Industrial Relations, MIOSHA and the requirements of the National Electrical Code, as interpreted by the Local Inspection Division. All these codes, rules, and regulations are hereby incorporated into this specification.
- B. Drawings and other specification sections shall govern in those instances where requirements are greater than those specified in the above standards.
- C. Wiring methods used shall be suitable for the installation and use in conformity with the provisions of the National Electric Code. Listed or labeled equipment shall be used or installed in accordance with any instructions included in the listing or labeling.
- D. Comply with specification requirements which are in excess of code requirements and not in conflict with same.
- E. The Contractor shall secure all permits and certificates of inspection incidental to his work, required by the foregoing authorities. All such certificates shall be delivered to the Owner in duplicate, before final payment on contract will be allowed. The Contractor shall pay all fees, charges and other expenses in connection therewith.

1.5 INTERFERENCES

- A. Before installing any of this work, the Contractor shall see that it does not interfere with clearances for the erection of finish beams, columns, pilasters, walls, ducts, and other structural, mechanical, or architectural members as shown on the drawings. If any work is so installed and later the architectural design cannot be followed, electrical contractor shall, at his own expense, make such changes in his work as the Architect or Engineer may direct to permit the completion of the other work in accordance with the drawings and specifications.
- B. It shall be the duty of the Contractor to report any interferences between his work and that of any other Contractor to the Engineer as soon as they are discovered. The Engineer will determine which equipment shall be relocated regardless of which was first installed.

1.6 MATERIALS AND WORKMANSHIP

- A. All work shall be installed in a practical and workmanlike manner by competent workers, skilled in their branch of the trade.
- B. Unless expressly specified or indicated on the drawings to the contrary, all materials shall be new and free from defects and shall be the best of their several kinds.
- C. Where materials, equipment and fixtures are recessed in fire rated walls, ceilings, soffits or floors, provide the necessary fire rated covers or box construction to maintain the fire rating.

- D. During installation and construction, enclosures, equipment, controls, controllers, circuit protective devices, and other like items, shall be protected against entry of foreign matter; and be vacuum cleaned both inside and outside before testing and operating and repainting if required.
- E. During the construction operation and at its completion, the Contractor shall remove all debris and excess materials caused by his work and he shall leave the area of the operation broom clean.

1.7 ACCEPTANCE

- A. As a precedent to requesting a final inspection, submit written statements regarding the following:
 - 1. All work required by contract is completed.
 - 2. All tests required by these specifications have been performed. Include a dated copy of all test results signed by the persons performing the test and the witnesses of the test.
 - 3. The Owner's Representative has been instructed in the operation and maintenance of the electrical systems. This shall include training by Manufacturer's Representatives as well as by the installers. Indicate the date of the instructions and the names of the Owner's representative.
 - 4. Certificates of inspections from authorities having jurisdiction.
 - 5. Spare items and parts as called for in specifications, to the Owner, obtain a written receipt and supply a copy of these receipts to the Engineer.
 - 6. Written warranty and first years' service. Provide extended warranty where applicable.
 - 7. A listing of the various Electrical Trades, their equipment suppliers, etc., including each firm's contact name, telephone number, emergency telephone number, etc. to the Owner for use during building warranty period.
 - 8. Copies of "Receipts from the Owner" for all "Spare" items turned over to him.
 - 9. A complete set of record "as built" drawings on mylar. "As built" drawings shall include all addenda and change orders as well as any and all changes required in the field.
 - 10. Required operating and maintenance instructions and wiring diagrams on all equipment and systems to the Owner's operating personnel.

1.8 RELATED SECTIONS

- A. Division 01 - Closeout Submittals.
- B. Division 22 - Plumbing
- C. Division 23 - Heating, Ventilating, and Air-Conditioning (HVAC)

1.9 SUBSTITUTIONS

- A. Refer to Section 01 2500 – Substitution Procedures.

PART 2 - PRODUCTS – NOT USED**PART 3 - EXECUTION – NOT USED****END OF SECTION 26 0000**

SECTION 26 0501 - MINOR ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Electrical demolition.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 - EXECUTION

3.1 PERFORMANCE REQUIREMENTS

- A. Refer to Section 02 4119 "Selective Demolition."

3.2 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as shown on Drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition drawings are based on casual field observation and existing record documents.
- D. Report discrepancies to Architect/Engineer before disturbing existing installation.
- E. Beginning of demolition means installer accepts existing conditions.

3.3 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- C. Existing Fire Alarm System: Remove portion of existing system as shown on drawings.
- D. Existing Telephone System: Remove portion of existing system as shown on drawings.
- E. Where concrete slabs are shown to be sawcut and removed, verify locations of conduits in or under the slab using x-ray or other method.

3.4 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Remove, all existing electrical installations, except where shown to be reused. Coordinate to accommodate new construction.
- B. Remove abandoned wiring to source of supply.
- C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors that remain, and patch surfaces.
- D. Disconnect all existing outlets and remove devices, unless noted otherwise. Remove abandoned outlets if conduit servicing them is abandoned and removed.
- E. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- F. Repair adjacent construction and finishes damaged during demolition and extension work.
- G. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- H. Extend existing installations using materials and methods as specified.

END OF SECTION 26 0501

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper building wire.
 - 2. Metal-clad cable, Type MC.
 - 3. Fire-alarm wire and cable.
 - 4. Connectors and splices.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Copper building wire.
 - 2. Metal-clad cable, Type MC.
 - 3. Fire-alarm wire and cable.
 - 4. Connectors and splices.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 or ASTM B496 for stranded conductors.
- D. Conductor Insulation:
 - 1. Type NM. Comply with UL 83 and UL 719.
 - 2. Type THHN and Type THWN-2. Comply with UL 83.
 - 3. Type XHHW-2. Comply with UL 44.

2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

2. Comply with UL 1569.
 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- C. Circuits:
1. Single circuit.
 2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.
- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors
- E. Ground Conductor: Insulated.
- F. Conductor Insulation:
1. Type TFN/THHN/THWN-2. Comply with UL 83.
- G. Armor: Steel or aluminum, interlocked.

2.3 FIRE-ALARM WIRE AND CABLE

- A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- B. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG unless other size is recommended by system manufacturer.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- C. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NRTL listed for fire-alarm and cable tray installation, plenum rated.

2.4 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

- C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Copper or aluminum.
 - 2. Type: One or two hole with standard barrels.
 - 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
 - 1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. ASD/VFD Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.
- B. Feeders: Type THHN/THWN-2, single conductors in raceway.
- C. Branch Circuits: Type THHN/THWN-2, single conductors in raceway.
- D. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.
- E. ASD/VFD Output Circuits: Type THHN/THWN-2 in metal conduit.

3.3 INSTALLATION, GENERAL

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points in accordance with Section 26 0533.13 "Conduits for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

- A. Comply with NFPA 72.
- B. Wiring Method: Install wiring in metal pathway.
 - 1. Install plenum cable in environmental airspaces, including plenum ceilings.
 - 2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
 - a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
 - 3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
 - 4. Signaling Line Circuits: Power-limited fire-alarm cables may be installed in the same cable or pathway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.
- E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.
- F. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.
- G. Wiring to Remote Alarm Transmitting Device: 1 inch conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inch of slack.

3.6 IDENTIFICATION

- A. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 8413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Perform Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test conductors feeding the following critical equipment and services for compliance with requirements:
 - 2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grounding and bonding conductors.
 - 2. Grounding and bonding clamps.
 - 3. Grounding and bonding bushings.
 - 4. Grounding and bonding hubs.
 - 5. Grounding and bonding connectors.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product indicated.
- B. Field Quality-Control Submittals:
 - 1. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

- A. Equipment Grounding Conductor:
 - 1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. ASTM - Bare Copper Grounding and Bonding Conductor:
 - 1. Referenced Standards: Complying with one or more of the following:
 - a. Soft or Annealed Copper Wire: ASTM B3

2.2 GROUNDING AND BONDING CLAMPS

- A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications.
- B. Source Limitations: Obtain products from single manufacturer.
- C. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

- b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
- D. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp:
 - 1. General Characteristics:
 - a. Two pieces with stainless steel bolts.
 - b. Clamp Material: Silicon bronze, aluminum or brass.
 - c. Listed for outdoor use.
- E. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp:
 - 1. General Characteristics:
 - a. Clamp Material: Aluminum or brass.
 - b. Listed for outdoor use.
- F. UL KDER - Beam Grounding and Bonding Clamp:
 - 1. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.
- G. UL KDER - Exothermically Welded Connection:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ABB, Electrification Business.
 - b. ERICO; brand of nVent Electrical plc.
 - 2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures, and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- C. UL KDER - Bonding Bushing:
 - 1. General Characteristics: Threaded bushing with insulated throat.
- D. UL KDER - Grounding Bushing:
 - 1. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.4 GROUNDING AND BONDING HUBS

- A. Description: Hubs with certified grounding or bonding locknut.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- C. UL KDER - Grounding and Bonding Hub:
 - 1. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.5 GROUNDING AND BONDING CONNECTORS

- A. Source Limitations: Obtain products from single manufacturer.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
- C. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:
 - 1. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.
- D. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal:
 - 1. General Characteristics: Mechanical-type, aluminum or copper terminal with set screw.
- E. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector:
 - 1. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.
 - a. Copper or copper alloy.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

- B. Inspect test results of grounding system measured at point of electrical service equipment connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING CONDUCTORS

- A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
- B. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
- C. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- D. Underground Grounding Conductors: Install barecopper conductor, 2/0 AWG minimum unless otherwise indicated.
 - 1. Bury at least 30 inch below grade.

3.3 SELECTION OF CONNECTORS

- A. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors unless otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.4 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Techniques:
 - 1. Conductors:
 - a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

2. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
 - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 - b. Make connections with clean, bare metal at points of contact.
 - c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
 - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
 - f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
 - 2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.
 - g. Grounding and Bonding for Piping:
 - 1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
 - 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 - h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
 - i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.
3. Equipment Grounding:
 - a. Install insulated equipment grounding conductors with feeders and branch circuits.
 - b. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

- c. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
 3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
 - c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
- B. Nonconforming Work:
 1. Grounding system will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective components and retest.
- C. Collect, assemble, and submit test and inspection reports.
 1. Report measured ground resistances that exceed 5 ohms.

3.6 PROTECTION

- A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Support systems.
 - 2. Mounting, anchoring, and attachment components.
 - 3. Installation of fabricated metal supports.
 - 4. Installation of concrete bases.

1.2 DELEGATED DESIGN SERVICES

- A. Delegated Design Professionals: Engage qualified structural professional engineer to design hangers and supports for electrical systems.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.
 - f. Fasteners.
 - g. Anchors.
 - h. Saddles.
 - i. Brackets.
 - 2. Include rated capacities and furnished specialties and accessories.
- B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.
 - 1. Hangers. Include product data for components.
 - 2. Slotted support systems.
 - 3. Equipment supports.
 - 4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated Design Submittals: For hangers and supports for electrical systems.
 - 1. Include design calculations and details of hangers.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT SYSTEMS

- A. Steel Slotted Support Systems:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABB, Electrification Business
 - b. Allied Tube & Conduit; Atkore International
 - c. Atkore Unistrut
 - d. CADDY; brand of nVent Electrical plc
 - e. Cooper B-line; brand of Eaton, Electrical Sector
 - f. Flex-Strut Inc.
 - g. G-Strut
 - h. Gripple Inc.
 - i. Haydon Corporation
 - j. Metal Ties Innovation
 - k. MIRO Industries Inc.
 - l. Rocket Rack; Robroy Industries
 - m. Wesanco/ZSi-Foster; an Ideal Tridon Group Company
 - 2. Standard Features: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Material for Channel, Fittings, and Accessories: Galvanized steel
 - c. Channel Width: Selected for applicable load criteria
 - d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Aluminum Slotted Support Systems:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABB, Electrification Business
 - b. Atkore Unistrut

- c. Eaton
- d. Flex-Strut Inc.
- e. Haydon Corporation
- f. MKT Metal Manufacturing
- 2. Standard Features: Extruded-aluminum channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.
 - a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Material: 6063-T5 aluminum alloy.
 - c. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 - d. Channel Width: Selected for applicable load criteria
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Nonmetallic Slotted Support Systems:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allied Tube & Conduit; Atkore International
 - b. Atkore Unistrut
 - c. Champion Fiberglass, Inc
 - d. Cooper B-line; brand of Eaton, Electrical Sector
 - e. Fabco Plastics Wholesale Limited
 - f. G-Strut
 - g. Haydon Corporation
 - h. Seasafe, Inc.; AMICO, a Gibraltar Industries Company
 - 2. Standard Features: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center, in at least one surface.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Width: Selected for applicable load criteria.
 - c. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 - d. Fitting and Accessory Materials: Same as those for channels and angles.
 - e. Rated Strength: Selected to suit applicable load criteria.
 - f. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- D. Conduit and Cable Support Devices:
 - 1. Standard Features: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

- E. Support for Conductors in Vertical Conduit:
 - 1. Standard Features: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints:
 - 1. Standard Features: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

2.3 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

- A. Powder-Actuated Fasteners:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC
 - 2. Standard Features: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - e. MKT Fastening, LLC
 - 2. Standard Features: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
- C. Concrete Inserts:
 - 1. Standard Features: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
- D. Clamps for Attachment to Steel Structural Elements:
 - 1. Standard Features: MSS SP-58 units are suitable for attached structural element.
- E. Through Bolts:
 - 1. Standard Features: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.

- F. Toggle Bolts:
 - 1. Standard Features: All steel springhead type.
- G. Hanger Rods:
 - 1. Standard Features: Threaded steel.

PART 3 - EXECUTION

3.1 SELECTION OF HANGERS AND SUPPORTS

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERM as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter.
- B. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least **25** percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- C. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Hot Work: NFPA 51B.
 - 3. Work in Confined Spaces: NFPA 350.
 - 4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 5. Installation of Steel Conduit: NECA NEIS 101.
 - 6. Installation of Aluminum Conduit: NECA NEIS 102.
 - 7. Installation of Metal Cable Tray Systems: NECA NEIS 105.
 - 8. Installation of Nonmetallic Cable Tray Systems: NECA NEIS 111.
 - 9. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT may be supported by openings through structure members, in accordance with NFPA 70.
 - 2. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb.

3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - a. To Wood: Fasten with lag screws or through bolts.
 - b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch thick.
 - f. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - g. To Light Steel: Sheet metal screws.
 - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
 4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- D. Interfaces with Other Work:
1. Provide vibration controls with hangers and supports.
 2. Touchup Finishes:
 - a. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1) Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
 - b. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
 - c. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.
 3. Installation of Fabricated Metal Supports:
 - a. Provide site-fabricated metal supports.
 - b. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
 - c. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.
 4. Installation of Concrete Bases:
 - a. Provide concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
 - b. Use 3000 psi, 28-day compressive-strength concrete.
 - c. Anchor equipment to concrete base as follows:
 - 1) Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

- 2) Install anchor bolts to elevations required for proper attachment to supported equipment.
- 3) Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 26 0529

SECTION 26 0533.13 - CONDUITS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Type EMT-S duct raceways and elbows.
 - 2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
 - 3. Type FMC-S duct raceways.
 - 4. Type LFMC duct raceways.
 - 5. Type PVC duct raceways and fittings.
 - 6. Fittings for conduit, tubing, and cable.
 - 7. Electrically conductive corrosion-resistant compounds for threaded conduit.
 - 8. Solvent cements.
- B. Related Requirements:
 - 1. Section 26 0519 "Low-Voltage for Electrical Power Conductors and Cables" for nonmetallic underground conduit with conductors (Type NUCC).

1.2 DEFINITIONS

- A. Conduit: A structure containing one or more duct raceways.
- B. Duct Raceway: A single enclosed raceway for conductors or cable.
- C. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Type EMT-S duct raceways and elbows.
 - 2. Type ERMC-S duct raceways, elbows, couplings, and nipples.
 - 3. Type FMC-S and Type FMC-A duct raceways.
 - 4. Type LFMC duct raceways.
 - 5. Type PVC duct raceways and fittings.
 - 6. Fittings for conduit, tubing, and cable.
 - 7. Electrically conductive corrosion-resistant compounds for threaded conduit.
 - 8. Solvent cements.

PART 2 - PRODUCTS**2.1 TYPE EMT-S DUCT RACEWAYS AND ELBOWS**

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2. Listing Criteria: UL CCN FJMX; including UL 797.
- B. Source Quality Control:
 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:
 1. Material: Steel.
 2. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size: 3/4".
 - d. Colors: As indicated on Drawings.

2.2 TYPE ERM-S DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

- A. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN DYIX; including UL 6.
- B. Source Quality Control:
 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERM-S-G), Elbows, Couplings, and Nipples:
 1. Exterior Coating: Zinc.
 2. Options:
 - a. Interior Coating: Zinc with organic top coating.
 - b. Minimum Trade Size: 3/4".
 - c. Colors: As indicated on Drawings.

2.3 TYPE FMC-S DUCT RACEWAYS

- A. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN DXUZ; including UL 1.
- B. Source Quality Control:
 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):
 1. Material: Steel.
 2. Options:
 - a. Minimum Trade Size: 3/4".

2.4 TYPE LFMC DUCT RACEWAYS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN DXHR; including UL 360.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):
 - 1. Material: Steel.
 - 2. Options:
 - a. Minimum Trade Size: 3/4".

2.5 TYPE PVC DUCT RACEWAYS AND FITTINGS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN DZYR; including UL 651.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:
 - 1. Dimensional Specifications: Schedule 40.
 - 2. Options:
 - a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
 - b. Markings: For use with maximum 90 deg C wire.
- D. UL DZYR - Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
 - 1. Dimensional Specifications: Schedule 80.
 - 2. Options:
 - a. Minimum Trade Size: Metric designator 16 (trade size 1/2).
 - b. Markings: For use with maximum 90 deg C wire.

2.6 FITTINGS FOR CONDUIT, TUBING, AND CABLE

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DWTT - Fittings for Type ERM C Duct Raceways:
 - 1. Listing Criteria: UL CCN DWTT; including UL 514B.
 - 2. Options:
 - a. Material: Steel.
 - b. Coupling Method: Threaded.
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- D. UL FKAV - Fittings for Type EMT Duct Raceways:
 - 1. Listing Criteria: UL CCN FKAV; including UL 514B.
 - 2. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.
 - c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.
- E. UL ILNR - Fittings for Type FMC Duct Raceways:
 - 1. Listing Criteria: UL CCN ILNR; including UL 514B.
- F. UL DXAS - Fittings for Type LFMC Duct Raceways:
 - 1. Listing Criteria: UL CCN DXAS; including UL 514B.

2.7 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN FOIZ; including UL Subject 2419.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:

2.8 SOLVENT CEMENTS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN DWTT; including UL 514B.

- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL DWTT - Solvent Cements for Type PVC Duct Raceways and Fittings.

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.
- B. Outdoors:
 - 1. Exposed and Subject to Severe Physical Damage: ERM C.
 - 2. Exposed and Subject to Physical Damage: ERM C.
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - 3. Exposed and Not Subject to Physical Damage: EMT.
 - 4. Concealed Aboveground: EMT.
 - 5. Direct Buried: PVC-80.
 - 6. Concrete Encased Not in Trench: PVC-40.
 - 7. Concrete Encased in Trench: PVC-40.
 - 8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- C. Indoors:
 - 1. Hazardous Classified Locations: ERM C.
 - 2. Exposed and Subject to Severe Physical Damage: ERM C. Locations include the following:
 - a. Loading docks.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 - 3. Exposed and Subject to Physical Damage: ERM C. Locations include the following:
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - b. Stub-ups to above suspended ceilings.
 - 4. Exposed and Not Subject to Physical Damage: EMT.
 - 5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 6. Damp or Wet Locations: Corrosion-resistant EMT.
 - 7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
- D. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.
 - 1. ERM C: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
 - 2. Type ERMCS: Article 344 of NFPA 70 and NECA NEIS 101.
 - 3. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
 - 4. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
 - 5. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
 - 6. Expansion Fittings: NEMA FB 2.40.
 - 7. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. General Requirements for Installation of Duct Raceways:
 - a. Complete duct raceway installation before starting conductor installation.
 - b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
 - c. Install no more than equivalent of three 90-degree bends in conduit run. Support within 12 inch of changes in direction.
 - d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
 - e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
 - f. Support conduit within 12 inch of enclosures to which attached.
 - g. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following points:
 - 1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2) Where an underground service duct raceway enters a building or structure.
 - 3) Conduit extending from interior to exterior of building.
 - 4) Conduit extending into pressurized duct raceway and equipment.
 - 5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - 6) Where otherwise required by NFPA 70.
 - h. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
 - i. Keep duct raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.
 - j. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.

- k. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.
 - l. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
 - 1) Termination fittings with shoulders do not require two locknuts.
 - m. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- 2. Types ERM:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.
 - 3. Types FMC and LFMC:
 - a. Provide a maximum of 72 inch of flexible conduit for recessed and semirecessed luminaires and equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 4. Types PVC:
 - a. Do not install Type PVC conduit where ambient temperature exceeds 122 deg F. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
 - b. Comply with manufacturer's published instructions for solvent welding and fittings.
 - 5. Duct Raceways Embedded in Slabs:
 - a. Run duct raceways larger than metric designator 27 (trade size 1) below concrete slab.
 - b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.
 - c. Arrange duct raceways to ensure that each is surrounded by minimum of 1 inch of concrete without voids.
 - d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.
 - 6. Stub-ups to Above Recessed Ceilings:
 - a. Provide EMT for duct raceways.
 - b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
 - 7. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:
 - a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. Install insulated throat metal grounding bushings on service conduits.

8. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.
 - a. EMT: Provide setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
 - b. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.
 9. Expansion-Joint Fittings:
 - a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft.
 - b. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - c. Install expansion fittings at locations where conduits cross building or structure expansion joints.
 - d. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 10. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.
 11. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.
 - a. Provide warning signs.
- D. Interfaces with Other Work:
1. Coordinate with Section 07 8413 "Penetration Firestopping" for installation of firestopping at penetrations of fire-rated floor and wall assemblies.
 2. Coordinate with Section 26 0529 "Hangers and Supports for Electrical Systems" for installation of conduit hangers and supports.

3.3 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 26 0533.13

SECTION 26 0533.16 - BOXES AND COVERS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Metallic outlet boxes, device boxes, rings, and covers.
 - 2. Nonmetallic outlet boxes, device boxes, rings, and covers.
 - 3. Junction boxes and pull boxes.
 - 4. Cover plates for device boxes.
 - 5. Hoods for outlet boxes.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Metallic outlet boxes, device boxes, rings, and covers.
 - 2. Nonmetallic outlet boxes, device boxes, rings, and covers.
 - 3. Junction boxes and pull boxes.
 - 4. Cover plates for device boxes.
 - 5. Hoods for outlet boxes.
- B. Shop Drawings:
 - 1. Shop drawings for floor boxes.

PART 2 - PRODUCTS**2.1 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS**

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN QCIT; including UL 514A.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL QCIT - Metallic Outlet Boxes and Covers:
 - 1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
 - 2. Options:
 - a. Material: Sheet steel.
 - b. Sheet Metal Depth: Minimum 2 inch.
 - c. Cast-Metal Depth: Minimum 2.4 inch.

- d. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb.
 - e. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.
- D. UL QCIT - Metallic Conduit Bodies:
 - 1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
- E. UL QCIT - Metallic Device Boxes:
 - 1. Description: Box with provisions for mounting wiring device directly to box.
 - 2. Options:
 - a. Material: Sheet steel.
 - b. Sheet Metal Depth: minimum 2 inch.
 - c. Cast-Metal Depth: minimum 2.4 inch.
- F. UL QCIT - Metallic Extension Rings:
 - 1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both and to accommodate building finishes.
- G. UL QCIT - Metallic Floor Boxes and Floor Box Covers:
 - 1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.
 - 2. Refer to the Drawings for additional information.
- H. UL QCIT - Metallic Concrete Boxes and Covers:
 - 1. Description: Box intended for use in poured concrete.

2.2 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. Listing Criteria: UL CCN QCMZ; including UL 514C.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL QCMZ - Nonmetallic Outlet Boxes and Covers:
 - 1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
- D. UL QCMZ - Nonmetallic Conduit Bodies:
 - 1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

- E. UL QCMZ - Nonmetallic Device Boxes:
 - 1. Description: Box with provisions for mounting wiring device directly to box.
- F. UL QCMZ - Nonmetallic Extension Rings:
 - 1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.
- G. UL QCMZ - Nonmetallic Floor Boxes and Floor Box Covers:
 - 1. Description: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

2.3 JUNCTION BOXES AND PULL BOXES

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. Listing Criteria: UL CCN BGUZ; including UL 50 and UL 50E.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
 - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.
- C. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 1 unless otherwise indicated.
- D. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 1 unless otherwise indicated.
- E. UL BGUZ - Indoor Polymeric Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 1 unless otherwise indicated.
- F. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 3R unless otherwise indicated.

- G. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 4 unless otherwise indicated.
- H. UL BGUZ - Outdoor Polymeric Junction and Pull Boxes:
 - 1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
 - 2. Options:
 - a. Degree of Protection: Type 3R unless otherwise indicated.

2.4 COVER PLATES FOR DEVICE BOXES

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. Listing Criteria: UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 - 3. Wallplate-Securing Screws: Metal with head color to match wallplate finish.
- B. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:
 - 1. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.032 inch thick, Type 302/304 non-magnetic stainless steel with brushed finish.
- D. UL QCIT or QCMZ - Nonmetallic Cover Plates for Device Boxes:
 - 1. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.
 - c. Color: White.

2.5 HOODS FOR OUTLET BOXES

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. Listing Criteria:
 - a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
 - b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.

3. Mounts to box using fasteners different from wiring device.
- B. Source Quality Control:
 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
- C. UL QCIT or QCMZ - Retractable or Reattachable Hoods for Outlet Boxes:
 1. Options:
 - a. Provides clear, weatherproof, "while-in-use" cover.

PART 3 - EXECUTION

3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.
- B. Degree of Protection:
 1. Outdoors:
 - a. Type 3R unless otherwise indicated.
 - b. Locations Exposed to Hosedown: Type 4.
 - c. Locations Subject to Potential Flooding: Type 6P.
 - d. Locations Exposed to Corrosive Agents: Type 4X.
 2. Indoors:
 - a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 12.
 - c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
 - d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
 - e. Locations Exposed to Hosedown: Type 4.
 - f. Locations Exposed to Corrosive Agents: Type 4X.
- C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:
 1. Provide cast-metal boxes.
 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 1. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
 2. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
2. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements.
3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
5. Locate boxes so that cover or plate will not span different building finishes.
6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
9. Set metal floor boxes level and flush with finished floor surface.
10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 - a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 - b. Provide gaskets for wallplates and covers.
14. Identification: Provide labels for boxes and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - c. Label each box with engraved metal or laminated-plastic nameplate.

3.3 CLEANING

- A. Remove construction dust and debris from boxes before installing wallplates, covers, and hoods.

3.4 PROTECTION

- A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 0533.16

SECTION 26 0533.23 - SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Surface metal raceways and fittings.
 - 2. Surface nonmetallic raceways.
 - 3. Strut-type channel raceways and fittings.
 - 4. Wireways and auxiliary gutters.
 - 5. Section 26 0526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 QUALIFICATIONS

- A. Electrical Power Testing (EPT) Technician III: Possessing active NICET EPT Level III certification. Able to manage switching procedures; conduct tests of complex equipment; analyze test and equipment data; plan a job; and lead a team. Has experience performing NFPA 70B, IEEE, and NETA electrical tests.
- B. Electrical Power Testing (EPT) Technician IV: Possessing active NICET EPT Level IV certification. Able to conduct tests of complex metering and relay systems; evaluate tests, test equipment, test results, and power system performance; recommend actions to maintain or improve system performance; and lead multi-team projects.
- C. Electrical Power Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site electrical testing supervisors must possess active NICET EPT Technician III certification.
- D. Communications Testing and Inspecting Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have BICSI Technician (TECH) certification and documented training, and be experienced with testing communications equipment in accordance with BICSI testing standards.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SURFACE METAL RACEWAYS AND FITTINGS

- A. Source Quality Control:
1. Samples:
 - a. Surface Metallic Raceway Nonmetallic Cover Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch long.
- B. UL RJBT - Surface Metal Raceways and Fittings with Metal Covers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated
 - b. MonoSystems, Inc
 - c. Wiremold; Legrand North America, LLC
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJBT; including UL 5.
 3. Standard Features:
 - a. Galvanized steel base with snap-on covers.
 - b. Manufacturer's standard enamel finish in color selected by Architect.
 - c. Wiring Channels: Dual. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
- C. UL RJBT - Surface Metal Raceways and Fittings with Nonmetallic Covers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Union Products International, Inc.
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJBT; including UL 5.
 3. Standard Features:
 - a. UL 94, V-0 requirements for self-extinguishing characteristics.
 - b. Galvanized steel base with snap-on covers.
 - c. Provide texture and color selected by Architect from manufacturer's standard colors.

- d. Wiring Channels: Dual. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

2.3 SURFACE NONMETALLIC RACEWAYS

- A. Source Quality Control:
 - 1. Samples:
 - a. Surface Nonmetallic Raceway Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch long.
- B. UL RJTX - Surface Nonmetallic Raceways and Fittings with Nonmetallic Covers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. HellermannTyton
 - b. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated
 - c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated
 - d. Panduit Corp
 - e. Wiremold; Legrand North America, LLC
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJTX; including UL 5A.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
 - 3. Standard Features:
 - a. Provide texture and color selected by Architect from manufacturer's standard colors.
 - b. Wiring Channels: Dual. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.
- C. UL RJTX - Surface Nonmetallic Raceways and Fittings with Metallic Covers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RJTX; including UL 5A.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
 - 3. Standard Features:
 - a. Manufacturer's standard enamel finish in color selected by Architect.
 - b. Wiring Channels: Dual. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

2.4 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

- A. Source Quality Control:
 - 1. Samples:
 - a. Strut-Type Channel Raceway Nonmetallic Covers for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch long.
- B. UL RIUU - Strut-Type Channel Raceways and Fittings with Metallic Covers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABB, Electrification Business
 - b. Atkore Unistrut
 - c. Cooper B-line; brand of Eaton, Electrical Sector
 - d. Power-Strut; Atkore International
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RIUU; including UL 5B.
 - 3. Standard Features:
 - a. Manufacturer's standard enamel finish in color selected by Architect.
- C. UL RIUU - Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN RIUU; including UL 5B.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
 - 3. Standard Features:
 - a. UL 94, V-0 requirements for self-extinguishing characteristics.
 - b. Provide texture and color selected by Architect from manufacturer's standard colors.

2.5 WIREWAYS AND AUXILIARY GUTTERS

- A. Source Quality Control:
 - 1. Samples:
 - a. Nonmetallic Wireway and Auxiliary Gutter Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch long.

- B. UL ZOYX - Metal Wireways and Auxiliary Gutters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABB, Electrification Business
 - b. Cooper B-line; brand of Eaton, Electrical Sector
 - c. Hoffman; brand of nVent Electrical plc
 - d. MonoSystems, Inc
 - e. Square D; Schneider Electric USA
 - f. Wiegmann; brand of Hubbell Electrical Solutions; Hubbell Incorporated
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ZOYX; including UL 870.
 3. Standard Features:
 - a. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
 - b. Finish: Manufacturer's standard enamel finish.
 - c. Wireway Covers: Screw-cover type unless otherwise indicated.
 4. Other Available Features Required by the Project:
 - a. Degree of Protection: Type 1 unless otherwise indicated.
- C. UL ZOYX - Nonmetallic Wireways and Auxiliary Gutters:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hoffman; brand of nVent Electrical plc
 2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
 - a. UL CCN ZOYX; including UL 870.
 - b. UL 94, V-0 requirements for self-extinguishing characteristics.
 3. Standard Features:
 - a. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings must match and mate with wireways as required for complete system.
 - b. PVC Solvents and Adhesives: As recommended by wireway manufacturer.
 - c. Material:
 - 1) Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover must be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections must be flanged and have stainless steel screws and oil-resistant gaskets.
 - 2) PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

PART 3 - EXECUTION**3.1 INSTALLATION OF SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS**

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:
 - 1. Electrical Construction: ICC IBC, ICC IFB, NFPA 1, NFPA 70, and NECA NEIS 1.
 - 2. Electrical Safety: NFPA 70E.
 - 3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
 - 4. Communications Work: BICSI N1.
 - 5. Work in Confined Spaces: NFPA 350.
 - 6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
 - 7. Auxiliary Gutters: Article 366 of NFPA 70.
 - 8. Surface Metal Raceway: Article 386 of NFPA 70.
 - 9. Surface Nonmetallic Raceway: Article 388 of NFPA 70.
 - 10. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Install surface raceways only where indicated on Drawings.
 - 2. Install surface raceway with a minimum 2 inch radius control at bend points.
 - 3. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's published instructions. Tape and glue are unacceptable support methods.
- D. Interfaces with Other Work:
 - 1. Identification: Provide labels for surface raceways and associated electrical equipment.
 - a. Identify field-installed conductors, interconnecting wiring, and components.
 - b. Provide warning signs.
 - 2. Coordinate installation of new products with existing conditions.

3.2 FIELD QUALITY CONTROL OF SURFACE RACEWAYS

- A. Adminstrant for Electrical Power Tests and Inspections:
 - 1. Owner will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections.

- B. Administrant for Communications Tests and Inspections:
 - 1. Owner will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
 - 2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
 - 3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
 - 4. Administer and perform tests and inspections.
- C. Tests and Inspections:
 - 1. Perform manufacturer's recommended tests and inspections.
 - 2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.
- D. Nonconforming Work:
 - 1. Boxes and covers will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- E. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.3 CLEANING

- A. Remove construction dust and debris from surface raceways before installing covers.

3.4 PROTECTION

- A. After installation, protect surface raceways from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 0533.23

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Labels.
 - 2. Extruded insulating tubing.
 - 3. Bands.
 - 4. Tapes and stencils.
 - 5. Tags.
 - 6. Signs.
 - 7. Cable ties.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS**2.1 LABELS**

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.
- B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Champion America
 - c. LEM Products Inc.
 - d. Marking Services Inc.
 - e. Panduit Corp

- C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, polyester flexible label with acrylic pressure-sensitive adhesive.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Brother International Corporation
 - c. LEM Products Inc.
 - d. Marking Services Inc.
 - e. Panduit Corp
 2. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
 3. Marker for Labels:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
- D. UL PGDQ2 - Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Brother International Corporation
 - c. LEM Products Inc.
 - d. Marking Services Inc.
 - e. Panduit Corp
 2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inch for raceway and conductors.
 - b. 3-1/2 by 5 inch for equipment.
 - c. As required by authorities having jurisdiction.

2.2 EXTRUDED INSULATING TUBING

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.
- B. UL YDPU2 - Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of 200 deg F.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Panduit Corp

2.3 BANDS

- A. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Marking Services Inc.
 - c. Panduit Corp
- B. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch long, with diameters sized to suit diameters and that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Marking Services Inc.
 - c. Panduit Corp

2.4 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Champion America
 - c. Ideal Industries, Inc.
 - d. Marking Services Inc.
 - e. Panduit Corp
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Marking Services Inc.
- C. Tape and Stencil: 4 inch wide black stripes on 10 inch centers placed diagonally over orange background and are 12 inch wide. Stop stripes at legends.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. LEM Products Inc.
 - b. Marking Services Inc.

- c. Seton Identification Products; a Brady Corporation company
- D. Floor Marking Tape: 2 inch wide, 5 mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Seton Identification Products; a Brady Corporation company

2.5 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Marking Services Inc.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. LEM Products Inc.
 - d. Marking Services Inc.
 - e. Panduit Corp

2.6 SIGNS

- A. Baked-Enamel Signs:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Champion America
 - d. Marking Services Inc.
 - 2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 3. 1/4 inch grommets in corners for mounting.
 - 4. Nominal Size: 7 by 10 inch.

- B. Metal-Backed Butyrate Signs:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Champion America
 - c. Marking Services Inc.
 2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396 inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
 3. 1/4 inch grommets in corners for mounting.
 4. Nominal Size: 10 by 14 inch.
- C. Laminated Acrylic or Melamine Plastic Signs:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation
 - b. Carlton Industries, LP
 - c. Marking Services Inc.
 2. Engraved legend.
 3. Thickness:
 - a. For signs up to 20 sq. inch, minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. inch, 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners with 1/4 inch grommets in corners for mounting.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Ideal Industries, Inc.
 2. Marking Services Inc.
 3. Panduit Corp
- B. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.
- C. UL ZODZ - General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.

3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- D. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black.
- E. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 7000 psi.
 3. UL 94 Flame Rating: 94V-0.
 4. Temperature Range: Minus 50 to plus 284 deg F.
 5. Color: Black.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

- A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:
1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
 2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft above finished floor.
- B. Pipe and Conduit Labeling: Comply with ASME A13.1 and IEEE C2.
- C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
1. Color must be factory applied or field applied for sizes larger than 6 AWG when permitted by authorities having jurisdiction.
 2. Colors for 208Y/120 V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 3. Colors for 240 V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 4. Colors for 480Y/277 V Circuits:
 - a. Phase A: Brown.

- b. Phase B: Orange.
 - c. Phase C: Yellow.
- 5. Color for Neutral (Grounded Conductor): White.
- 6. Color for Equipment Ground: Bare copper.
- 7. Color for Isolated Ground: Green with two or more yellow stripes.
- D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.
- E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.
- F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:
 - 1. "EMERGENCY POWER."
 - 2. "POWER."
 - 3. "UPS."
- G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- H. Junction Boxes, 1000 V or Less: For conductors junction boxes use vinyl wraparound labels to identify phase.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
 - 2. Identify system voltage and system or service type with black letters on orange field.
- I. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
 - 2. Identify system voltage and system or service type with black letters on orange field.
- J. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Label cover plate with the following information, in the order listed:
 - 1. Panelboard designation.
 - 2. Colon or dash.
 - 3. Branch circuit number.

- K. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- L. Equipment Identification Labels:
1. Black letters on white field.
 2. Indoor Equipment: Self-adhesive label.
 3. Outdoor Equipment: Laminated acrylic or melamine sign.
 4. Equipment to Be Labeled:
 - a. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
 - b. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of self-adhesive, engraved, laminated acrylic or melamine label.
 - c. Enclosures and electrical cabinets.
 - d. Access doors and panels for concealed electrical items.
 - e. Switchgear.
 - f. Switchboards.
 - g. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
 - h. Substations.
 - i. Emergency system boxes and enclosures.
 - j. Motor-control centers.
 - k. Enclosed switches.
 - l. Enclosed circuit breakers.
 - m. Enclosed controllers.
 - n. Variable-speed controllers.
 - o. Push-button stations.
 - p. Power-transfer equipment.
 - q. Contactors.
 - r. Remote-controlled switches, dimmer modules, and control devices.
 - s. Uninterruptible power supplies.
 - t. Battery-inverter units.
 - u. Battery racks.
 - v. Power-generating units.
 - w. Monitoring and control equipment.
- M. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.

3.3 SELECTION OF SIGNS AND HAZARD MARKINGS

- A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

- B. Signs, labels, and tags required for personnel safety must comply with the following standards:
 - 1. Safety Colors: NEMA Z535.1.
 - 2. Facility Safety Signs: NEMA Z535.2.
 - 3. Safety Symbols: NEMA Z535.3.
 - 4. Product Safety Signs and Labels: NEMA Z535.4.
 - 5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.
- C. Electrical Hazard Warnings:
 - 1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E requirements for arc-flash hazard warning labels.
 - 2. Raceways and Cables Carrying Circuits at More Than 1000 V:
 - a. Black letters on orange field.
 - b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
 - 3. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 4. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."
- D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.
 - 1. Apply to exterior of door, cover, or other access.
 - 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- E. Operating Instruction Signs: Self-adhesive labels.
- F. Emergency Operating Instruction Signs: Self-adhesive labels with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for.

3.4 INSTALLATION

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- C. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

- D. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- E. Install identifying devices before installing acoustical ceilings and similar concealment.
- F. Verify identity of item before installing identification products.
- G. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- H. Apply identification devices to surfaces that require finish after completing finish work.
- I. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.
- K. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.
- L. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.
- M. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- N. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.
- O. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.
- P. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.
- Q. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
 - 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- R. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

- S. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.
- T. Metal Tags:
 - 1. Place in location with high visibility and accessibility.
 - 2. Secure using general-purpose cable ties.
- U. Nonmetallic Preprinted Tags:
 - 1. Place in location with high visibility and accessibility.
 - 2. Secure using general-purpose cable ties.
- V. Baked-Enamel Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
- W. Metal-Backed Butyrate Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
- X. Laminated Acrylic or Melamine Plastic Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

END OF SECTION 26 0553

SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Indoor occupancy and vacancy sensors.
 - 2. Switchbox-mounted occupancy/vacancy sensors.
 - 3. Conductors and cables.
- B. Related Requirements:
 - 1. Section 26 2726 "Wiring Devices" for manual light switches.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Indoor occupancy and vacancy sensors.
 - 2. Switchbox-mounted occupancy/vacancy sensors.
 - 3. Digital timer light switch.
 - 4. Conductors and cables.
- B. Shop Drawings:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - c. Accessories.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Field quality-control reports.

1.3 WARRANTY

- A. Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within warranty period.
 - 1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 WALL BOX DIMMERS

- A. Wall-Box Dimmers:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Arrow Hart).

- b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Lutron Electronics Co., Inc.
 - e. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
 - 3. Control: Continuously adjustable slider; with single-pole or three-way switching.
 - 4. Standards: Comply with UL 1472.
 - 5. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - a. 600 W; dimmers shall require no derating when ganged with other devices.
 - 6. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.
- B. Wall-Box 0 – 10V Dimmers:
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Lutron Electronics Co., Inc.
 - e. Wattstopper/Legrand.
 - 2. Description: 120/277 switch combined with a 0 – 10V dimmer.
 - 3. Control: Continuously adjustable slider; with single-pole or three-way switching.
 - 4. Standards: Comply with UL 1472.

2.2 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
- 1. Eaton.
 - 2. Hubbell.
 - 3. Legrand.
- B. General Requirements for Sensors:
- 1. Wall or ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
 - 2. Dual technology.
 - 3. Separate power pack.
 - 4. Hardwired.
 - 5. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 6. Operation:
 - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

- b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 7. Sensor Output: Sensor is powered from the power pack.
 - 8. Power: Line voltage.
 - 9. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
 - 10. Mounting:
 - a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 - 12. Bypass Switch: Override the "on" function in case of sensor failure.
 - 13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Wall or ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
- 1. Sensitivity Adjustment: Separate for each sensing technology.
 - 2. Detector Sensitivity: Detect occurrences of 6 inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch, and detect a person of average size and weight moving not less than 12 inch in either a horizontal or a vertical manner at an approximate speed of 12 inch/s.
 - 3. Detection Coverage: Select sensor to detect occupancy anywhere within the space where installed.

2.3 WALL BOX MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
- 1. Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - 2. Eaton.
 - 3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - 4. Legrand.
 - 5. Leviton Manufacturing Co., Inc.

- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox using hardwired connection.
 - 1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
 - 4. Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA LED load at 277 V, and 800 W incandescent.
- C. Wall Switch Sensor Light Switch, Dual Technology:
 - 1. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
 - 2. Standards: Comply with UL 20.
 - 3. Adjustable time delay of up to 20 minutes.
 - 4. Able to be locked to Manual-On mode.
 - 5. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.
- D. Wall Sensor Light Switch, Passive Infrared:
 - 1. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using passive infrared technology.
 - 2. Standards: Comply with UL 20.
 - 3. Adjustable time delay of up to 20 minutes.
 - 4. Able to be locked to Manual-On mode.
 - 5. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.
- E. Dimming Wall Switch Sensor Light Switch, Dual Technology or PIR:
 - 1. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) or PIR only technology combined with 0 to 10V dimming slider.
 - 2. Standards: Comply with UL 20.
 - 3. Suitable for 120V or 277V operation.
 - 4. Adjustable time delay of up to 20 minutes.
 - 5. Able to be locked to Manual-On mode.
- F. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc.

2.4 LOW VOLTAGE MANUAL SWITCH

- A. Single button, momentary low voltage switch compatible with vacancy sensors and power packs/room controllers.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 22 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SENSORS

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.

3.3 INSTALLATION OF CONTACTORS

- A. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 INSTALLATION OF WIRING

- A. Wiring Method: Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
- B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

- C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring in accordance with Section 26 0553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Nonconforming Work:
 - 1. Lighting control devices will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- C. Manufacturer Services:
 - 1. Engage factory-authorized service representative to support field tests and inspections.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to one visit to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

END OF SECTION 26 0923

SECTION 26 0943.13 - DIGITAL-NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. System Software Interfaces.
 - 2. System Backbone and Integration Equipment.
 - 3. Wired Networked Devices.
 - 4. Wireless Networked Devices.
- B. Related Requirements:
 - 1. Section 26 2726 "Wiring Devices" for wired switches and dimmers and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

- A. Data Bus: A wired interface used to communicate with connected devices.
- B. Device: A collective term for bus or wireless connected devices, including fluorescent ballasts, LED drivers, incandescent luminaires, manual switches, switching relays, sensors, and similar.
- C. Global: Communication between devices in otherwise separate spaces using a bridging device or system controller.
- D. Group: A set of devices that communicate together.
- E. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- F. Scene: Digital light level associated with a preset.
- G. System Backbone: Devices used to connect and manage otherwise separate spaces, including bridging devices and gateways or system controllers. Used to expose devices to software configuration via TCP/IP.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Coordination Meeting(s): For digital-network lighting controls. Conduct meeting(s) at Project site 921 Alger Street SE, Grand Rapids, MI 49507.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect, Construction Manager, and Owner's Commissioning Authority of scheduled meeting dates.
 - 2. Engage factory-authorized service representative to attend preinstallation conference and review the submittal drawing, sequence of operation, and device installation best practices with Project team.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. Product Specification Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.
 - 2. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.
 - 3. Other Diagrams and Operational Descriptions - as needed to indicate system operation or interaction with other system(s).
- B. Shop Drawings:
 - 1. Riser Diagrams showing device wiring connections of system backbone and typical per room/area type.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Contracts:
 - 1. Hardware and Software Operation Manuals
 - 2. Maintenance service agreement.
 - 3. Software service agreement.
- B. Warranty documentation.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Phone Support: Toll-free technical support available from manufacturer through an online tool to schedule a technical support appointment and provide 24/7 emergency support.
 - 2. Remote Support: Manufacturer capable of providing remote support and ability to virtually connect with customers to address issues with visual guidance overlaid on images of real-world objects.
 - 3. On-Site Support: Manufacturer capable of providing a 72-hour, on-site response time within the continental United States.
 - 4. Service Contracts: Manufacturer capable of providing service contracts for continued on-site and remote support of the lighting control system post-installation for terms up to 10 years from substantial completion, including:
 - a. Remote and on-site emergency response.
 - b. Remote system performance checks.
 - c. Remote diagnostics.
 - d. Replacement parts.

1.7 WARRANTY

- A. Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control hardware.

- b. Faulty operation of lighting control firmware.
- 2. Minimum Warranty Period: Five years from date of shipment.

PART 2 - PRODUCTS

2.1 SYSTEM COMPLIANCE

- A. System components manufactured in accordance with UL 916 and UL 924 standards where applicable.
- B. System components manufactured in accordance with CFR Title 47, Part 15 standards where applicable.
- C. System components manufactured in accordance with ISED Canada RSS-247 standards where applicable.
- D. System components manufactured in accordance with IFT-008-2015 and NOM-208-SCFI-2016 standards where applicable.
- E. System listed as qualified under DesignLights Consortium Networked Lighting Control System Specification v5.0.
- F. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SYSTEM PERFORMANCE REQUIREMENTS

- A. System Architecture:
 - 1. System architecture based upon the following concepts:
 - a. Networkable intelligent lighting control devices.
 - b. Standalone lighting control zones using distributed intelligence.
 - c. Optional system backbone for remote, time-based, and global operation.
 - 2. Intelligent lighting control devices with individually addressable network communication capability and having one or more basic lighting control components including: occupancy sensor, photosensor, relay, dimming output, contact closure input, analog 0-10 V(dc) input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure permissible to minimize overall system device count.
 - 3. System capable of interfacing directly with networked luminaires such that either low-voltage network cabling or wireless RF communication is used to interconnect networked luminaires with control components such as sensors, switches, and system backbone.
 - 4. Networked luminaires and intelligent lighting control devices support individual (unique) configuration of device settings and properties, with such configuration residing within the networked luminaires and intelligent control devices.

5. Lighting control zones consisting of one or more networked luminaires and intelligent lighting control devices capable of providing automatic control from sensors (occupancy and/or photosensor) and manual control from local wall stations without requiring connection to a higher-level system backbone.
 - a. Lighting control zones (wired and wireless) support at least 128 devices per zone.
 - b. Capable of being networked with a higher-level system backbone to provide time-based control, control from inputs or systems external to control zone, and remote configuration and monitoring through a software interface.
 6. Networked luminaires and intelligent lighting control devices with distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones operate according to their defined default settings and sequence of operations.
 7. System to include one or more system controllers that provide time-based control.
 8. System controller provides means of connecting the lighting control system to a system software interface and building management systems via BACnet/IP or BACnet MS/TP protocol.
 9. System controller supports both low-voltage wired and wireless RF communication within a single controller device.
 10. System devices support firmware update, either remotely or from within the application space, for purposes of upgrading functionality at a later date.
 11. System capable of reporting lighting system events and performance data to management software for display and analysis.
- B. Wired Networked Control Zone Characteristics:
1. Connections to devices within a wired networked lighting control zone and to backbone components accomplished with a single type of low-voltage network cable, compliant with CAT5e specifications or higher. Use of mixed types of low-voltage network cables is unacceptable.
 2. Devices connected in "daisy-chain" topology. "Hub-and-spoke" topology, requiring all individual networked devices to be connected to a central component, is unacceptable, to reduce the total amount of network cable required for each control zone.
 3. Following proper installation and provision of power, all networked devices connected with low-voltage network cable must automatically form a functional lighting control zone without requiring any type of programming, regardless of the programming mechanism (e.g. software application, handheld remote, pushbutton).
 - a. The "out of box" default sequence of operation is intended to provide typical sequence of operation to minimize the system startup and programming requirements and to also have functional lighting control operation prior to system startup and programming.
 4. System software capable of automatic discovery of all connected devices without requiring any provisioning of system or zone addresses.
 5. Networked devices capable of detecting improper communication wiring and LED notification to alert installation/startup personnel.

6. Networked control devices suitable for control of egress or emergency light sources without additional, externally mounted UL 924 shunting or 0-10 V(dc) disconnect devices, to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. Capable of supporting the following sequence of operation:
 - a. Low-Voltage Power Sensing: Devices automatically provide 100 percent light level upon detection of loss of power sensed via low-voltage network cable connection where applicable.
 - b. Line-Voltage Power Sensing: Devices listed as UL 924 emergency relays which automatically close load-control relay and provide 100 percent light output upon detection of loss of power sensed via line voltage connection to normal power.
7. Global Control Zones: Networked luminaires and intelligent lighting control devices located in different areas able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span multiple areas. Occupancy, photosensor inhibit, and switch commands available across multiple controllers.
8. Wired Networked Wall Station Scene-Control Capabilities:
 - a. Preset Scenes that activate a specific combination of light levels across multiple local and global channels.
 - b. Local Profile Support: Profile Scenes that modify the sequence of operation for devices in the area (group) in response to a button press to dynamically optimize occupant experience and lighting energy usage.
 - 1) Wall stations able to manually start and stop local profiles, or local profile capable of ending after a specific duration of time between five minutes and 12 hours.
 - 2) Configurable Parameters:
 - a) Fixture light level.
 - b) Occupancy time delay.
 - c) Response to occupancy sensors (including enabling/disabling response).
 - d) Response to daylight sensors (including enabling/disabling response).
 - e) Enabling/disabling wall stations.
 - c. Three-Way or Multi-Way Control: Multiple wall stations capable of controlling the same local and global control zones, to support "multi-way" preset scene and profile scene control.
- C. Wireless Networked Control Zone Characteristics:
 1. No wired connections between networked devices required for the purposes of system communications.
 2. Multiple wireless networking protocols supported:
 - a. Standards-based, distributed star topology type of protocol for 900 MHz communication, to support lighting control applications and IoT applications.
 - b. Bluetooth standard protocol for 2.4 GHz communication that supports direct connection to smartphone or tablet, to support device configuration, control applications, and IoT without requiring the use of a system backbone.

3. Wireless network must be self-healing, such that the loss of backbone or local communication between devices does not result in the loss of local control of lights in the space.
4. Wireless network communication must support uniform and instant response such that all luminaires in a lighting control zone respond immediately and synchronously in response to a sensor or wall station signal.
5. Communication of control signals from sensors and wall stations to networked luminaires and wireless load-control devices occur directly, without any communication, interpretation, or translation of information through a backbone device such as a wireless access point, communication bridge, or gateway.
6. All wireless communication between lighting control components supports the following five tiers of security measures.
 - a. Data encryption.
 - b. Firmware protection.
 - c. Tamper-proof hardware.
 - d. Authenticated user access.
 - e. Mutual device authentication.
7. Wireless devices use AES encryption to secure communication with a unique encryption key generated for each programmed site.
8. Wireless devices use signed firmware to ensure that unmodified, authentic software is always installed.
9. Wireless networked devices capable of communicating a minimum distance of 150 ft. between devices under typical site conditions accounting for typical environmental conditions and building construction materials encountered within commercial indoor lighting environments.
10. Minimum Line-of-Sight Communication Range: 1000 ft. under ideal environmental conditions.
11. Wireless devices self-identify when communication to system controller cannot be accomplished or when communication to the system controller is lost.
 - a. Self-identification not required for wireless switches or battery-powered devices.
12. Wireless devices self-establish connection to system controller through other devices if direct communication cannot be accomplished or when communication to system controller is lost.
 - a. Communication path formation to utilize existing, wireless networked devices located between system controller and respective end devices.
 - b. No additional hardware for formation of networked communication path between a system controller and end devices required.
 - c. Automatic connection not required for wireless switches or battery-powered devices.
13. Networked control devices suitable for control of egress or emergency light sources without additional, externally mounted UL 924 shunting or 0-10 V(dc) disconnect devices, to provide a compliant sequence of operation while reducing the overall installation and wiring costs of the system. Capable of supporting the following sequence of operation:
 - a. Line-Voltage Power Sensing: Devices listed as UL 924 emergency relays that automatically close load-control relay and provide 100 percent light output upon detection of loss of power sensed via line voltage connection to normal power.

- b. Normal-Power-Broadcast Sensing: Devices listed as UL 924 emergency relays that automatically close load-control relay and provide 100 percent light output upon loss of a wireless normal-power broadcast from devices connected to normal power.
- D. System Integration Capabilities:
 - 1. Capable of interface with third-party building management systems (BMS) to support two-way communication using BACnet/IP protocol, BACnet MS/TP protocol, and RESTful API including the following system integration capabilities:
 - a. "Write" messages for control of individual devices, including control of relay and dimming output.
 - b. "Write" messages for control of groups of devices through a single command, including control of relay and dimming output of all devices.
 - c. "Read" messages for individual device status information.
 - 1) Available status will vary based on device type and capabilities, which may include relay state, dimming output, power measurement, occupancy sensor status, and photosensor light measurement.
 - d. "Read" messages for group status information for occupancy, relay state, and dimming output.
 - e. Activation of pre-defined system Global Profiles.
- E. Supported Sequence of Operations:
 - 1. Control Zones:
 - a. Local Control Zones: Networked luminaires and intelligent lighting control devices installed in an area (also referred to as a group of devices) capable of transmitting and tracking occupancy sensor, photosensor, and manual switch information within at least 48 unique control zones to support different and reconfigurable sequences of operation within area. These will also be referred to as local control zones.
 - b. Adjacent Control Zones: Networked luminaires and intelligent lighting control devices capable of tracking occupancy broadcasts from adjacent zones. When this feature is enabled, luminaire output for a vacant zone will reduce to a configurable dimmed state if one or more adjacent zones are occupied. Luminaires will turn off when both primary and adjacent zones are vacant.
 - c. Global Control Zones: Networked luminaires and intelligent lighting control devices located in different areas able to transmit and track information within at least 128 system-wide control zones to support required sequences of operation that may span across multiple areas. Occupancy, photosensor inhibit, and switch commands available across multiple controllers.
 - 2. Wall Station Capabilities:
 - a. Wall stations support the following capabilities:
 - 1) On/Off of a local or global control zone.
 - 2) Continuous dimming control of light level of a local or global control zone.
 - b. Multi-Way Control: Multiple wall stations capable of controlling the same local or global control zones, to support "multi-way" switching and dimming control.

3. Occupancy Sensing Capabilities:
 - a. Occupancy sensors configurable to control a local or global zone.
 - b. Multiple occupancy sensors capable of controlling the same local or global zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
 - c. Occupancy sensing sequence of operation modes:
 - 1) On/Off Occupancy Sensing.
 - 2) Partial-On Occupancy Sensing.
 - 3) Partial-Off Occupancy Sensing.
 - 4) Vacancy Sensing (Manual-On / Automatic-Off).
 - d. On/Off, Partial-On, and Partial-Off Occupancy Sensing Modes Sequence of Operation:
 - 1) Occupancy automatically turn lights on to a designated level when occupancy is detected. Designated occupied light level support at least 100 dimming levels.
 - 2) Occupancy sensors automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. Designated unoccupied dim level support at least 100 dimming levels.
 - 3) System capable of combining Partial-Off and Full-Off operation by dimming lights to a designated level when vacant and turning the lights off completely after an additional time delay.
 - 4) Photosensor readings, if enabled in occupancy sensing control zone, automatically adjust light levels during occupied or unoccupied conditions as necessary.
 - 5) Wall station activation changes the dimming level or turn lights off as selected by the occupant. Lights optionally remain in this manually specified light level until the zone becomes vacant. Upon vacancy, normal sequence of operation resumes.
 - e. Vacancy Sensing or Manual-On/Automatic-Off Mode Sequence of Operation:
 - 1) Activation of a wall station is required turn lights on. System capable of programming the zone to turn on to either a designated light level or previous user-set light level. Initially occupying the space without using a wall station must not result in lights turning on.
 - 2) Occupancy sensors automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected. Designated unoccupied dim level support at least 100 dimming levels.
 - 3) System capable of dimming the lights when vacant and then turning the lights off completely after an additional time delay.
 - 4) System capable of an "automatic grace period" immediately following detection of vacancy, during which time any detected occupancy results in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.
 - 5) Photosensor readings, if enabled in the Occupancy Sensing control zone, capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary.

- 6) Wall station interaction changes the dimming level or turn lights off as selected by occupant. Lights remain at manually specified light level until zone becomes vacant; normal sequence of operation resumes upon vacancy.
 - f. Occupancy time delays before dimming or shutting off lights separately programmable for all control zones from 15 seconds to 2 hours.
- 4. Photosensor Sensing Capabilities (Automatic Daylight Sensing):
 - a. Photosensor devices configurable to control a local zone.
 - b. Photosensor-Based Control:
 - 1) Continuous Dimming: Control zone automatically adjusts dimming output in response to photosensor readings, to maintain a minimum light level consisting of both electric light and daylight sources. Photosensor response configurable to adjust set point and dimming rates.
- 5. Schedule Capabilities:
 - a. System capable of time schedules for time-of-day to override devices including offsets from dusk and dawn.
 - b. System capable of providing a visible "blink warning" five minutes prior to the end of the schedule.
 - c. Wall stations may be programmed to provide timed extensions/overrides that turn the lights on for an additional time period.
 - 1) Timed override/extension duration programmable for each individual device, zone of devices, or customized group of devices, from five minutes to 12 hours.
- 6. Global Profile Capabilities:
 - a. System capable of automatically modifying the sequence of operation for selected devices in response to any of the following:
 - 1) Time-of-day schedule.
 - 2) Contact closure input state.
 - 3) Manually triggered wired wall station input.
 - 4) RS-232/RS-485 command to wired input device.
 - 5) BACnet input command.
 - b. Global Profile Capabilities:
 - 1) Global Profiles stored within and executed from the system controller (via internal timeclock). Dedicated software host or server is not required to be online to support automatic scheduling and/or operation of Global Profiles.
 - 2) Global Profile time-of-day schedules capable of recurrence settings including daily, specific days of week, every "n" number of days, weekly, monthly, and yearly. Lighting control global profile schedules support definition of start date, end date, end after "n" recurrences, or never ending.
 - 3) Daylight savings time adjustments capable of being performed automatically, if desired.
 - 4) Global Profile holiday schedules follow recurrent settings for specific U.S. holiday dates regardless if they always occur on a specific date or are determined by day/week of the month.

- 5) Global Profiles capable of being scheduled to run according to timed offsets relative to sunrise or sunset. Sunrise/sunset times automatically derived from location information using an astronomical clock.
- 6) Software management interface capable of displaying a graphic calendar view of profile schedules for each control zone.
- 7) Global Profiles capable of manual activation directly from system controller, specially programmed wired input devices, scene-capable wired wall stations, and software management interface.
- 8) Global Profiles selectable to apply to a single device, zone of devices, or customized group of devices.
- 9) Global Profile Configurable Parameters:
 - a) Fixture light level.
 - b) Occupancy time delay.
 - c) Response to occupancy sensors (including enabling/disabling response).
 - d) Response to daylight sensors (including enabling/disabling response).
 - e) Enabling/disabling of wall stations.
- c. Local and Global Profiles backed up and stored on software's host server such that Profile backup can be applied to a replacement system controller or wired wall station.
7. System supports automated demand response capabilities with automatic reduction of light level to at least three levels of demand response, configurable for each output device.

2.3 SYSTEMS SOFTWARE INTERFACES

- A. Management Interface:
 1. Web-based management interface for remote system control, live status monitoring, and configuration of lighting control settings and schedules.
 2. Compatible with industry-standard web browser clients.
 3. Minimum of 100 unique password-protected user accounts.
 4. Minimum of three user permission levels: read-only, read and change settings, and full administrative system access.
 5. Capable of restricting access for user accounts to specific devices within the system.
 6. All system devices capable of being given user-defined names.
 7. Device identification information displayed in the Management interface including:
 - a. Model number.
 - b. Model description.
 - c. Serial number or network ID.
 - d. Manufacturing date code.
 - e. Custom label.
 - f. Parent network device.
 8. Management interface capable of displaying live status of a networked luminaire or intelligent control device including:
 - a. Luminaire on/off status.
 - b. Dim level.

- c. Power consumption.
 - d. Device temperature.
 - e. PIR occupancy sensor status.
 - f. Microphonic occupancy sensor status.
 - g. Remaining occupancy time delay.
 - h. Photosensor reading.
 - i. Active Profiles.
 - 9. Management interface capable of displaying and modifying the current active settings of a networked luminaire or intelligent control device including:
 - a. Dimming trim levels.
 - b. Occupancy sensor and photosensor enable/disable.
 - c. Occupancy sensor time delay and light level settings.
 - d. Occupancy sensor response (normal or vacancy).
 - e. Photosensor setpoints and transition time delays.
 - 10. Management interface capable of applying settings changes for a zone of devices or a group of selected devices using a single action that does not require the user to apply settings changes for each individual device.
 - 11. Management interface capable of compiling a printable network inventory report.
 - 12. Management interface capable of compiling a printable report detailing all system profiles.
 - 13. All sensitive information stored encrypted.
 - 14. System software updates available for automatic download and installation via the Internet.
- B. System Energy Analysis and Reporting:
- 1. Intuitive graphical screens to facilitate simple viewing of system energy performance.
 - 2. Energy Scorecard: Summarized display that indicates calculated energy savings in dollars or KWh.
 - 3. Software calculates allocation of energy savings by control measures including occupancy sensors, photosensors, and manual switching.
 - 4. Energy savings data calculated for the system as a whole.
 - 5. Time-scaled graph showing all relay transitions.
 - 6. Time-scaled graph showing zone occupancy time delays.
 - 7. Time-scaled graph showing the total light level.
 - 8. Software capable of storing information remotely onto an open-source, object-relational database, such as PostgreSQL.
 - 9. Data stored in the database will be accessed utilizing an open standard, application programming interface, such as Open Database Connectivity (ODBC).
- C. Visualization and Programming Interfaces:
- 1. System provides an optional web-based visualization interface that displays a graphical floorplan.
 - 2. Graphical floorplan will offer the following types of system visualization:
 - a. Full Device Option: Master graphic of entire building, by floor, showing each control device installed with zones outlined including:
 - 1) Controls embedded light fixtures.
 - 2) Controls devices not embedded in light fixtures.
 - 3) Daylight sensors.

- 4) Occupancy sensors.
 - 5) Wall switches and dimmers.
 - 6) Scene controllers.
 - 7) Networked relays.
 - 8) Wired bridges.
 - 9) System Controllers.
 - 10) Wired relay panels.
 - 11) Group outlines.
 - b. Group-Only Option: Master graphic of the entire building, by floor, showing only control groups outlined.
 - c. Pan and zoom commands supported to allow smaller areas to be displayed on a larger scale simply by panning and zooming each floor's master graphic.
 - d. Selecting any control device displays the following as applicable:
 - 1) Device catalog number.
 - 2) Device name and custom label.
 - 3) Device diagnostic information.
 - 4) Link to further information on device including status or current configuration.
3. Programming capabilities through the application will include the following:
 - a. Switch, occupancy sensor, and photosensor zone configuration.
 - b. Manual-on or automatic-on modes.
 - c. Turn-on and dim to dimming levels.
 - d. Occupancy sensor time delays and PIR sensitivity.
 - e. Dual technology occupancy sensors sensitivity.
 - f. Photosensor calibration adjustment and auto-setpoint.
 - g. Multiple photosensor zone offset.
 - h. Trim level settings.
 - i. Preset scene creation and copy for scene-capable devices.
 - j. Application of custom device labels to the Bluetooth Low-Energy Programming Devices and individual connected lighting control devices.
 - k. Fade rate settings.
- D. Smartphone Programming Interface for Wired and Wireless Devices:
 1. Interface provided for both Apple iOS and Android operating systems that allows configuration of lighting control settings.
 2. Application supports configuration of wireless networked control devices.
 - a. Application access granted with valid user name and password.
 - b. Access to program information governed by permission system that allows users to share access with other users and restrict access to those who should not be able to reconfigure the equipment.
 - c. Indication of signal strength where multiple Bluetooth Low-Energy Programming Devices are available for configuration.
 3. Application supports configuration or wired networked control devices.
 - a. Connected device access granted through user-defined passcode at initial install.
 - b. Indication of signal strength where multiple Bluetooth Low-Energy Programming Devices are available for configuration.
 4. Programming Capabilities:
 - a. Switch, occupancy sensor, and photosensor group configuration.

- b. Manual-on or automatic-on modes.
- c. Turn-on and dim to dimming levels.
- d. Occupancy sensor time delays and PIR sensitivity.
- e. Dual technology occupancy sensors sensitivity.
- f. Photosensor calibration adjustment and auto-setpoint.
- g. Multiple photosensor zone offset.
- h. Trim level settings.
- i. Preset scene creation.
- j. Application of custom device labels for individual connected lighting control devices.
- k. Fade rate settings.

2.4 SYSTEM BACKBONE AND SYSTEM INTEGRATION EQUIPMENT

- A. System Controller: Multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nECY or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 - 2. System Controller Processor: 32-bit microprocessor operating at a minimum of 1 GHz.
 - 3. System Controller Memory: Minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support operating system and databases.
 - 4. System Controller Functions:
 - a. Time-based control of downstream wired and wireless network devices.
 - b. Linking into an Ethernet network.
 - c. Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
 - d. Connection to various software interfaces, including management interface, historical database and analytics interface, and visualization interface.
 - 5. Integral web server to support system controller configuration and diagnostics with control and visualization of connected devices.
 - a. Web Server Control Interface:
 - 1) Display associated devices within the context of a graphical floorplan.
 - 2) Provide control of output-capable devices through virtual sliders, toggle buttons, preset level widgets, and transparent layers on floorplan.
 - 3) Control Capabilities:
 - a) Control of individual output devices, including control of relay state and analog dimming level where applicable.
 - b) Control of local lighting control zones, including control of relay state and analog dimming level where applicable.
 - c) Control of global lighting control zones, including control of relay state and analog dimming level where applicable.
 - d) Control of Global Profiles.

- b. Visualization Interface:
 - 1) Customizable display with the ability to superimpose colored, transparent layers representing real-time property values, including occupancy status, dimming level status, light level status, and online or offline status where applicable.
 - 2) Ad hoc display of trended information via an intuitive values-over-time graph.
 - 3) Report Creation:
 - a) Reports accept and graphically display trended status datasets for creator selected devices or zones of devices.
 - b) Report information displayed over a user-defined interval and date range.
 - c) Reports exportable to a standard CSV format.
 - 6. Minimum of three RJ-45 networked lighting control ports for connection to any of the following:
 - a. Graphical touch screen.
 - b. Wired communication bridges.
 - c. Direct connection to networked wired luminaires and intelligent lighting control devices (up to 128 total devices per port).
 - 7. Device will automatically detect all network-connected devices.
 - 8. Capable of managing and operating a minimum of 750 networked devices (wired or wireless) per system controller.
 - 9. Multiple System Controllers capable of connection via LAN for scalability to a minimum of 20,000 networked devices.
 - 10. Supports BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without additional protocol translation gateways.
 - a. BACnet MS/TP Connection Speed: 9600 to 115200 baud rate.
 - b. BACnet Testing Laboratory (BTL listed) using Device Profile BACnet Building Controller (B-BC) with outlined enhanced features.
 - 11. Integral FIPS 140-2, Level 1 cryptographic module.
 - 12. Supports RESTful API for control of BACnet objects, user management, date and time, and file management.
 - 13. NEMA 1 enclosure with Class 1 and Class 2 separation.
 - a. Power Supply Voltage: 120 to 277 V(ac).
 - 14. Automatic algorithm to eliminate redundant, wireless networked paths to streamline communication between the system controller and end devices.
 - 15. System Controller Security Provisions:
 - a. Disallow the use of default passwords and require passwords to be updated prior to use.
 - b. Support user role-based access, such as administrator, user, and viewer.
 - c. Signed firmware to ensure that unmodified, authentic software is always installed.
 - d. IP-based communication protected with strong encryption algorithms such as AES or TLS1.2+.
 - e. Prevent rollback of firmware to firmware versions with known, critical vulnerabilities.
 - f. Valid cybersecurity listing through a third party.
- Cellular Remote Access: Cellular router and modem for remote access.
- a. Router supports remote access to at least five system controllers on its local area network or network subnet.

- b. Remote access capable of device setting updates, schedule updates, system performance optimization, and diagnostics.
- c. Remote access enabled through outbound communication from router to an outside source. Solutions that begin communication via inbound requests for network access are unacceptable.
- d. Router supports outbound communication to manufacturer-hosted portal using TLS1.2 or greater in-transit encryption over a cellular or Ethernet connection.
- e. Router with integral firewall to prevent unauthorized access to devices connected to its local area network port.
- f. Router includes cellular SIM capable of connection to AT&T, T-Mobile, Sprint, US Cellular, Alaska Wireless, Telefonica, Tellus, Bell, or Sasktel networks where carrier service is available.
- g. Outbound communication from the router limited to whitelisted endpoints. Devices that allow unrestricted communication are unacceptable.
- h. Outbound communication from router includes only lighting control system information.

2.5 WIRED NETWORKED DEVICES

- A. Scene Controller Options:
 - 1. Number of Scenes: 4.
 - 2. Control Types Supported:
 - a. On/Off.
 - b. On/Off/Dimming.
 - c. Preset Level Scene Type.
 - d. On/Off/Dimming/Preset Level for Correlated Color Temperature.
 - e. Reprogramming of other devices within daisy-chained zone to implement user-selected lighting scene including manual start/stop from the scene controller, or optionally programmed automatic stop after a user-selectable duration between five minutes and 12 hours.
 - f. Selecting a lighting profile to be run by device's upstream controller to implement a selected lighting profile across multiple zones including manual start/stop from the scene controller, or optionally programmed automatic stop after a user selectable duration between five minutes and 12 hours.
 - 3. Color: White.
- B. Networked Graphic Wall Stations:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nTS Touchscreen or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 - 2. Mounting: Suitable for installation in single-gang switch box.
 - 3. Integral 7-inch capacitive full-color touch screen.
 - 4. Power via polarity insensitive Class 2 low-voltage 15 to 24V (dc) power supply.
 - 5. Device enables mobile application control of control zones and scenes through Bluetooth.

6. Communication over standard low-voltage network cabling with RJ-45 connectors.
 7. User-customizable screen saver utilizing uploaded image file in common file format including jpg, png, gif, bmp, or tif.
 8. Capable of configuration of all switches, dimmers, control zones, and lighting preset scenes via password-protected setup screens.
 9. Graphic Wall Station Options:
 - a. Number of Control Zones: Up to 16.
 - b. Number of Scenes: Up to 16.
 - c. Profile Scene Duration: User configurable from five minutes to 12 hours.
 - d. Color: White.
- C. Wired Networked DMX Interface Stations:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nPwDMX or comparable product by one of the following:
 - a. ETC.
 - b. Lutron.
 2. Description: Multi-protocol, bidirectional DMX512 playback (snapshot) and lighting control gateway.
 - a. Capable of control of networked luminaire or all normal power lighting load types.
 - b. Capable of control of DMX lighting through:
 - 1) DMX input for snapshot capture of lighting presets.
 - 2) Live control of intensity, hue, and saturation of configured DMX Zones from connected stations.
 - c. Integral LED indicators for power, network traffic, processor health, identify, DMX port configuration and status.
 - d. Support recall of up to 16 (total):
 - 1) Prerecorded scenes/snapshots for playback.
 - 2) DMX zones.
 - e. Capable of preset playback as activated by any connected control station.
 - f. Capable of DMX pass-through for real-time output of incoming DMX levels.
 - g. Support four universes of ANSI E1.31 sACN-Streaming ACN (sACN), including priorities, for snapshot capture and recall.
 - h. Support ANSI E1.20 RDM with PC-based software.
 - i. Act as an ANSI E1.33 RDMnet controller.
 3. General Requirements:
 - a. Operating Voltages:
 - 1) PoE Class 2 Device.
 - 2) 24 V(dc) (not used if using PoE), 7 W maximum power consumption.
 - b. Operating Temperature: Minus 32 to plus 113 deg F.
 - c. NEMA Type 1 enclosure.
 - 1) Enclosure Size: 10 inches wide by 13 inches high by 4.5 inches deep.

4. Features:
 - a. Lighting control ports supports:
 - 1) Communication through lighting control (RJ-45) ports that supply 40 mA of power to each device via standard Category 5e low-voltage network cabling.
 - 2) Detection of valid communication and blinking of a unique LED pattern to visually indicate a potential wiring issue.
 - b. DMX Ports:
 - 1) Comply with the requirements of ANSI E1.11 USITT DMX512-A standards.
 - 2) Configurable as Input or Outputs.
 - 3) Support ANSI E1.31 sACN.
 - 4) Support Pathway Secure Streaming ACN (ssACN).
 - 5) Comply with California Title 1.81.26.
 - 6) Comply with ANSI E1.20 RDM.
 - 7) Capable of withstanding fault voltages of up to 250 V(ac) without damage.
 - c. Dry contact closure input to connect with external control systems to control a lighting control zone or scene.
 - d. Ethernet Ports:
 - 1) Support IEEE 802.3af Power-over-Ethernet in absence of 24 V(dc).
 - 2) Support auto-negotiated 10/100MB connections speeds.
 - 3) Support IEEE 802.1AB Link Layer Discovery Protocol.
 - e. Test Functions:
 - 1) Operate without need of a configuration PC to check local wiring.
 - 2) Test connectivity with DMX lights and networked luminaire or all normal power lighting load types.
 - f. Complies with the following:
 - 1) RoHS 2011/65/EU + A1 2015/863.
 - 2) FCC.

2.6 WIRELESS NETWORKED DEVICES

- A. Wireless Networked Wall Switches, Dimmers:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; Rpod series or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 2. Mounting: Suitable for installation in single-gang switch box.
 3. Wireless Communication:
 - 1) Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - 2) Security: AES-128 bit.
 4. Power Supply: 120 to 277 V(ac).
 5. Mechanical push buttons provide tactile and LED user feedback during button press.
 6. Mechanical push buttons available with custom button labeling.
 7. Wall Switches and Dimmer Options:
 - a. Number of Control Zones: See drawings.

- b. Control Types Supported: On/Off and On/Off/Dimming.
 - 8. Scene Switch Options:
 - a. Number of Scenes: See drawings.
 - b. Control Types Supported: On/Off, On/Off/Dimming, and Preset Level Scene Type.
 - 9. Color: White.
- B. Wireless Networked Embedded Fixture Control Devices:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rIO or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 - 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 - 3. Power Supply: Standard low-voltage wiring typically associated with an LED driver.
 - 4. Suitable for installation within a luminaire such that the control device is not visible on the luminaire face.
 - 5. Devices available with integrated and remote antennas such that devices can be installed within sealed container without detriment to wireless strength.
 - 6. Antenna Color: White.
 - 7. Dimming Output: 0-10V .
 - 8. Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.
- C. Wireless Networked Indoor Load Controllers with Occupancy and Photosensors:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rLSXR or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 - 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 - 3. Detect the presence of human activity within space and fully control the on/off function of lights.
 - 4. Utilizes passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 - 5. Dual technology sensors used in locations where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions).

6. Dual technology sensors must have one sensing technology not motion dependent to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT), which detects both occupant motion and sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) are unacceptable.
 7. All sensing technologies are acoustically passive, meaning they do not transmit sound waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers and hearing devices). Acceptable detection technologies include Passive Infrared (PIR) and/or Microphonic technology. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 8. Sensor programming parameters available and configurable remotely.
 9. Ceiling, fixture, and junction box mounted sensors available, with multiple lens options available customized for specific applications.
 10. Integral daylight photosensor for programmable daylight harvesting.
 11. Photosensor includes adjustable illumination set-point and dead band to prevent the artificial light from cycling. Set-point and dead band capable of automatically calibrating through an "Automatic Set-Point Programming" procedure. Min and max dimming settings and set-point may be manually entered or modified.
 12. Dead band setting verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
 13. Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.
 14. Power Monitoring: Integral current measurements on output with 3 percent accuracy when measuring loads 225 mA or greater.
- D. Wireless Networked Indoor Occupancy and Photosensors:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rCMS PDT, rCMSB PDT or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 3. Detect the presence of human activity within space and fully control the on/off function of lights.
 4. Utilizes passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 5. Dual technology sensors used in locations where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions).

6. Dual technology sensors must have one sensing technology not motion dependent to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT), which detects both occupant motion and sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) are unacceptable.
 7. All sensing technologies acoustically passive, meaning they do not transmit sound waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers and hearing devices). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonic technology. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 8. Sensor programming parameters available and configurable remotely.
 9. Ceiling, fixture, and junction box mounted sensors available, with multiple lens options available customized for specific applications.
 10. Dry Contact Output: One integrated dry contact switching relay, capable of switching 100 mA at 24 V, resistive only.
 11. Integral daylight photosensor for programmable daylight harvesting.
 12. Photosensor includes adjustable illumination set-point and dead band to prevent the artificial light from cycling. Set-point and dead band capable of automatically calibrating through an "Automatic Set-Point Programming" procedure. Min and max dimming settings and set-point may be manually entered or modified.
 13. Dead band setting verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
- E. Wireless Networked Outdoor Occupancy and Photosensors:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rSDGR, rSBOR, rTLN or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 3. Mounting: Nipple mount with IP66 rating, or In-fixture mount with IP65 rating.
 4. Supply Voltage: 120 to 277 V(ac).
 5. Detect the presence of human activity within space and fully control the on/off function of lights.
 6. Utilizes passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 7. Sensors detect valid communication and blink a unique LED pattern to visually indicate a potential issue.
 8. Sensor programming parameters available and configurable remotely.
 9. Available with multiple lens options available for various mounting heights.
 10. Power Monitoring: Integral current measurements on output with 3 percent accuracy when measuring loads 225 mA or greater.
 11. Integral daylight photosensor for programmable daylight harvesting.

12. Photosensor includes adjustable illumination set-point and dead band to prevent the artificial light from cycling. Set-point and dead band capable of automatically calibrating through an "Automatic Set-Point Programming" procedure. Min and max dimming settings and set-point may be manually entered or modified.
 13. Dead band setting verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
 14. Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.
- F. Wireless Networked Indoor Embedded Sensors:
1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rES7 PDT, rSBG or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 3. Sensors consisting of occupancy sensors and dimming photosensor suitable for installation within a luminaire such that only the lens is visible on luminaire face.
 4. Power Supply: Standard low-voltage wiring typically associated with an LED driver.
 5. Devices available with integrated and remote antennas such that devices can be installed within sealed container without detriment to wireless strength.
 6. Antenna Color: White.
 7. Dimming Output: 0-10 V.
 8. Detect the presence of human activity within space and fully control the on/off function of lights.
 9. Utilizes passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
 10. Sensors detect valid communication and blink a unique LED pattern to visually indicate a potential issue.
 11. Sensor programming parameters available and configurable remotely.
 12. Available with multiple lens options available for various mounting heights.
 13. Integral daylight photosensor for programmable daylight harvesting.
 14. Photosensor includes adjustable illumination set-point and dead band to prevent artificial light from cycling. Set-point and dead band capable of automatically calibrating through an "Automatic Set-Point Programming" procedure. Min and max dimming settings and set-point may be manually entered or modified.
 15. Dead band setting verified and modified by sensor automatically every time lights cycle to accommodate physical changes in space (i.e., furniture layouts, lamp depreciation, or lamp outages).
 16. Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.

G. Wireless Networked Outdoor Embedded Sensors:

1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rMSOD, rSBG or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
3. Sensors consisting of occupancy sensors and dimming photosensor suitable for installation within a luminaire such that only the lens is visible on luminaire face.
4. Power Supply: Standard low-voltage wiring typically associated with an LED driver.
5. Color: Black.
6. Ingress Protection: Minimum IP66.
7. Devices available with remote antennas such that devices can be installed within sealed container without detriment to wireless strength.
8. Detect the presence of human activity within space and fully control the on/off function of lights.
9. Utilizes passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state, thus preventing false on conditions. Ultrasonic and Microwave-based sensing technologies are unacceptable.
10. Sensors detect valid communication and blink a unique LED pattern to visually indicate a potential issue.
11. Sensor programming parameters available and configurable remotely.
12. Available with multiple lens options available for various mounting heights.
13. Integral daylight photosensor for programmable daylight harvesting.
14. Photosensor includes adjustable illumination set-point and dead band to prevent artificial light from cycling. Set-point and dead band capable of automatically calibrating through an "Automatic Set-Point Programming" procedure. Min and max dimming settings and set-point may be manually entered or modified.
15. Dead band setting verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
16. Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.

H. Wireless Networked Power Packs:

1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; rPP series or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
3. Plenum rated.
4. Supply Voltage: 120 to 277 V(ac).

5. Relay Output: Class 1 relay rated for 20 A and 1.5 HP at 120 to 277 V(ac) and 5 A and 0.5 HP at 480 V(ac).
6. Dimming Output: 0-10 V(dc).
7. Sink Current: 150 mA at 0-10 V(dc).
8. Antenna Type: Integrated.
9. Programming parameters available and configurable remotely.
10. Mounting: Integral 1/2-inch chase nipple. Plastic clips into junction box are unacceptable.
11. Power Packs Options:
 - a. Power Pack capable of full 20-Amp switching of all normal power lighting load types, with optional 0-10V dimming output capable of up to 150 mA of sink current.
 - b. Power Packs capable of full 20-Amp switching of general purpose receptacle (plug-load) control.
 - c. Listing: UL 924 for control of emergency lighting circuits, field configurable for two distinct sequence of operation:
 - 1) Power sense of normal power feed, where unit powers and controls emergency circuit, and loss of the normal power sense circuit forces the power pack to shunt closed, go to full bright, and ignore all system commands until normal power is restored.
 - 2) Power loss detection, where unit powers and controls the emergency circuit. Loss of wireless broadcasts from a dedicated normal-power-connected device forces unit to shunt closed, go to full bright, and ignore all system commands until main power is restored.
 - d. Power Monitoring: Integral current measurements on output with 3 percent accuracy when measuring loads 425 mA or greater.
 - e. Chicago Plenum External Antenna:
 - 1) Mounting: 1/2-inch.
 - 2) Ingress Protection: IP67.
- I. Wireless Networked Communication Adapter:
 1. Basis-of-Design Product: Subject to compliance with requirements, provide nLight; Acuity Brands Lighting, Inc.; nECYD or comparable product by one of the following:
 - a. Cooper Industries, Inc.
 - b. Leviton Manufacturing Co., Inc.
 2. Wireless Communication:
 - a. Dual 900 MHz IEEE 802.15.4 based and 2.4 GHz, Version 4.0+ Bluetooth.
 - b. Security: AES-128 bit.
 3. Capable of supporting a minimum of 750 networked wireless devices per adapter.
 4. Interface: USB connection.
 5. Ingress Protection: Minimum IP66.
 6. Mounting: Integral 1/2-inch chase nipple. Minimum 16 ft. USB cable and optional cable extenders for remote mounting.

PART 3 - EXECUTION

3.1 INSTALLATION OF WIRING

- A. Wiring Method: Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.
 - 1. Comply with requirements for raceways and boxes specified in Section 26 0533.13 "Conduits for Electrical Systems," and Section 26 0533.16 "Boxes and Covers for Electrical Systems,"
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

- A. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 26 0553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with Section 26 0553 "Identification for Electrical Systems."
- C. Identify all controls with device address.
- D. Label each device cable within 6 inch of connection to bus power supply or termination block.

3.3 FIELD QUALITY CONTROL

- A. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- B. Tests and Inspections: Perform test inspections.
 - 1. Test each zone using local and remote control hardware.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
- C. Nonconforming Work:
 - 1. Lighting controls will be considered defective if they do not pass tests and inspections.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Field Test Reports: Prepare field test reports.
 - 1. Prepare functionality and inspection reports, including a certified report that identifies controls included and describes test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

2. Include list of all points created from actual tests of all addressed control points for lamps, ballasts, manual controls, and sensors.

3.4 REMOTE ACCESS

- A. Digital network lighting control system capable of remote access by manufacturer with the following features:
 1. System diagnostics including detection of fault condition in hardware or connected devices.
 2. Access to all connected devices for complete programming including scheduling of time-of-day events and device parameters necessary to meet required sequence of operations.
 3. Browser-based interface to verify system functionality.
 4. On-demand access to manufacturer technical support for remote troubleshooting, diagnostics, configuration, and programming.
 5. Owner training on the digital network lighting control system available remotely.
- B. Remote access system fully functional over commercial cellular connection or Internet-connected ethernet network.
- C. All hardware associated with remote access including cellular modem and cellular antenna are to remain on-site regardless of warranty or cellular contract status.

3.5 SYSTEM STARTUP

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's published instructions.
 2. Activate luminaires and verify that all maximum output levels match output levels detailed in an Owner-approved sequence of operations.
 3. Confirm correct communications wiring, initiate communications between control devices and controller/gateways, and program the lighting control system in accordance with approved configuration schedules, time-of-day schedules, and input override assignments.
 4. Program network devices to meet required sequence of operations.
 5. Program and verify all sequence of operations.
 6. Create backup of system programming.
 7. Assist in installation of system software on customer-provided workstation or server.
 8. Verify bidirectional communication of manufacturer-provided cellular router with manufacturer-managed remote access portal.
- B. Commissioning Walkthrough: Engage factory-authorized service representative to collaborate with third-party commissioning agent to demonstrate lighting control system functionality and verify the system meets the specified Project requirements.

3.6 CLOSEOUT ACTIVITIES

- A. Enhanced Documentation: Engage lighting system manufacturer to provide comprehensive system documentation including detailed programming, sequence of operation data per Project specifications, and related code requirements.
- B. Training: Engage lighting system manufacturer to provide comprehensive system overview, software overview, and documentation relating to system operation and maintenance.

3.7 PROTECTION

- A. After installation, protect digital network lighting controls from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

- A. Engage a factory-authorized service representative to perform on-site system adjustments.
 - 1. On-Site Occupancy Adjustments: When requested within 24 months from date of Substantial Completion, provide on-site settings adjustments to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 2. Prepare and submit report after each visit that details activities performed.
- B. Engage a factory-authorized service representative to perform remote system adjustments.
 - 1. Remote Occupancy Adjustments: When requested within 24 months from date of Substantial Completion and project registration with lighting control system manufacturer, provide remote settings adjustments to suit actual occupied conditions. Provide up to 2 sessions to Project during other-than-normal occupancy hours for this purpose.
 - a. System to include manufacturer-provided cellular communication hardware and connection to the system for a minimum of 24 months after substantial completion to allow for factory representative assistance with settings adjustments and system sustainment.
 - b. For the remaining duration of the maintenance term, or in the event cellular connectivity is not available, manufacturer assistance must be available through an Owner-provided, Internet-connected network.
 - 2. Prepare and submit report after each session that details activities performed.
- C. Maintenance Service Agreement:
 - 1. Beginning at Substantial Completion, verify that maintenance service agreement includes 12 months' full maintenance by manufacturer's authorized service representative.
 - 2. Include annual on-site and remote preventive maintenance.
 - 3. Preventative maintenance to include:
 - a. System diagnostic reports.

- b. System performance checks.
 - c. Device firmware updates.
 - d. Programming adjustment as required for proper lighting system operation.
 - e. Expedited factory direct warranty processing, replacement, and programming of defective components.
4. Verify that parts and supplies are manufacturer's authorized replacement parts and supplies.

END OF SECTION 26 0943.13

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. General-use switches.
 - 2. General-grade duplex straight-blade receptacles.
 - 3. Receptacles with ground-fault protective devices.
 - 4. Wall plates.
 - 5. Connectors, cords, and plugs.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. General-use switches.
 - 2. General-grade duplex straight-blade receptacles.
 - 3. Receptacles with ground-fault protective devices.
 - 4. Connectors, cords, and plugs.

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES

- A. Toggle Switch:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 - 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 3. General Characteristics:
 - a. Reference Standards: UL CCN WMUZ and UL 20.
 - 4. Options:
 - a. Device Color: White.
 - b. Configuration:
 - 1) General-duty, 120-277 V, 20 A, single pole, double pole, three way or four way as required.

- B. Toggle Switch with Forked Key Lock:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN WMUZ and UL 20.
 4. Options:
 - a. Device Color: White.
 - b. Configuration:
 - 1) 120-277 V, 20 A, single pole, double pole, three way or four way.

2.2 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

- A. Duplex Straight-Blade Receptacle:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Device Color: White.
 - b. Configuration:
 - 1) General-duty, NEMA 5-20R.
- B. Tamper-Resistant Duplex Straight-Blade Receptacle:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

- c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
- 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
- 4. Options:
 - a. Device Color: White.
 - b. Configuration:
 - 1) General-duty, NEMA 5-15R.

2.3 RECEPTACLES WITH GROUND-FAULT PROTECTIVE DEVICES

- A. Description: Receptacles containing GFCI device for use in accordance with NFPA 70.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. General Characteristics:
 - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
- C. General-Grade Duplex Straight-Blade Receptacle with GFCI Device:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 - 2. Options:
 - a. Device Color: White.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
- D. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.

2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN AWBZ, UL 498, UL 1699, and UL Subject 1699A.
 4. Options:
 - a. Device Color: White.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
- E. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
 4. Options:
 - a. Device Color: White.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
- 1)

2.4 CONNECTORS, CORDS, AND PLUGS

- A. Outdoor-Use, Watertight, Sealed Cord Connector:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Ericson Manufacturing Company.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN AXUT and UL 498.
 4. Options:
 - a. Configuration:
 - 1) NEMA 5-20.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Receptacles:
 - 1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.
- B. Cord Reels:
 - 1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
 - 2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SWITCHES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 - 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 3. Consult Architect for resolution of conflicting requirements.

3.3 INSTALLATION OF RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 - 2. Mounting Heights: Unless otherwise indicated in Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
 - 3. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
 - 4. Consult Architect for resolution of conflicting requirements.

3.4 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS

- A. Comply with manufacturer's instructions.

3.5 FIELD QUALITY CONTROL OF RECEPTACLES

- A. Tests and Inspections:
 - 1. Insert and remove test plug to verify that device is securely mounted.

2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Device will be considered defective if it does not pass tests and inspections.
5. Remove and replace defective units and retest.

3.6 ADJUSTING

- A. Cord Reels and Fittings: Adjust spring mechanisms and moving parts of cord reels and fittings to function smoothly, and lubricate as recommended in writing by manufacturer.

3.7 PROTECTION

- A. Devices:
 1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
 2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- B. Cord Reels and Fittings:
 1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.
- C. Connectors, Cords, and Plugs:
 1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 26 2726

SECTION 26 2923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformer.
- C. DDC: Direct digital control.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC/VFD: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include mounting and attachment details.
 - 4. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
 - 1. Include the following:
 - a. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

- b. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
- c. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
- d. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 VARIABLE-FREQUENCY MOTOR CONTROLLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB, Electrification Business.
 - 2. Danfoss, Inc.
 - 3. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:
 - 1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A or UL 508C.
- B. Application: Variable torque.

- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
 2. Input AC Voltage Unbalance: Not exceeding 3 percent.
 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 4. Minimum Efficiency: 96 percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.
 7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
 8. Humidity Rating: Less than 95 percent (noncondensing).
 9. Altitude Rating: Not exceeding 3300 feet.
 10. Vibration Withstand: Comply with NEMA ICS 61800-2.
 11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus 5 percent.
 14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 16 or 32 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
- I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 999.9 seconds.

4. Deceleration: 0.1 to 999.9 seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under- and overvoltage trips.
 4. Inverter overcurrent trips.
 5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 6. Critical frequency rejection, with three selectable, adjustable deadbands.
 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor-overtemperature fault.
- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- O. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFC input current rating.

2.3 CONTROLS AND INDICATION

- A. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- B. Historical Logging Information and Displays:
 1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- C. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
 1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- D. Control Signal Interfaces:
 1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
 4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.

- c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- E. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.

2.4 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Provide a 3% or 5% line reactor.
- B. Output Filtering: Provide the manufacturer recommended output filter for the VFC installation configuration indicated on the Drawings.

2.5 OPTIONAL FEATURES

- A. Damper control circuit with end-of-travel feedback capability.
- B. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.6 ENCLOSURES

- A. VFC Enclosures: NEMA 250, Type 1 or Type 12 as indicated to comply with environmental conditions at installed location.

2.7 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
 - 1. Push Buttons: Unguarded.
 - 2. Pilot Lights: Push to test.
 - 3. Selector Switches: Rotary type.
 - 4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- B. Reversible NC/NO bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 - 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

- E. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.
- F. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 0529 "Hangers and Supports for Electrical Systems."
- B. Install fuses in control circuits if not factory installed.
- C. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system.
- B. Bundle, train, and support wiring in enclosures.

3.4 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform manufacturer recommended tests and inspections with the assistance of a factory-authorized service representative.
- C. Prepare test and inspection reports, including a certified report that identifies the VFC and describes results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
 - 1. For each VFC, record adjustable parameter settings and include as part of the Closeout Submittals required.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 26 2923

SECTION 26 5119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes interior LED luminaires and supports. Refer also to the Schedule on the Drawings.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of luminaires.
 - 4. Include emergency lighting units, including batteries and chargers.
 - 5. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 - 6. Photometric data and adjustment factors based on laboratory tests.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications:
 - 1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.8 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 LUMINAIRE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
- C. Recessed luminaires shall comply with NEMA LE 4.
- D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- F. California Title 24 compliant.

2.2 LUMINAIRE CONSTRUCTION.

- A. Housings:
 - 1. Finish as indicated.
 - 2. Mounting configuration as indicated.
 - 3. Integral junction box with conduit fittings.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Diffusers and Globes:
 - 1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
 - 3. Lens Thickness: At least 0.125-inch minimum unless otherwise indicated.
- D. With integral mounting provisions.
- E. Standards:
 - 1. ENERGY STAR certified.
 - 2. RoHS compliant.
 - 3. UL Listing: Listed for damp location.
- F. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- G. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for sheet steel.
- H. Stainless Steel:
 - 1. Manufacturer's standard grade.
 - 2. Manufacturer's standard type, ASTM A240/240M.
- I. Galvanized Steel: ASTM A653/A653M.
- J. Aluminum: ASTM B209.

2.3 METAL FINISHES

- A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.4 LUMINAIRE SUPPORT

- A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION**3.1 EXAMINATION**

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaires:
 - 1. Secured to outlet box.
 - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.

3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaires:

1. Attached to structural members in walls.
2. Do not attach luminaires directly to gypsum board.

G. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

H. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 5119

SECTION 31 1000 - SITE CLEARING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Protecting existing vegetation to remain.
 2. Removing existing vegetation.
 3. Clearing and grubbing.
 4. Stripping and stockpiling topsoil.
 5. Removing above- and below-grade site improvements.
 6. Disconnecting, capping or sealing, and removing site utilities.
 7. Temporary erosion and sedimentation control.

1.2 DEFINITIONS

- A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.
- D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.
- E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."
- F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.3 MATERIAL OWNERSHIP

- A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
1. Use sufficiently detailed photographs or video recordings.

2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.
- B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.5 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.
- B. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises.
- C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
- E. Tree- and Plant-Protection Zones: Protect according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."
- F. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 31 2000 "Earth Moving."
 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."

- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. Protect trees and plants remaining on-site according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

- A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
 - 1. Arrange with utility companies to shut off indicated utilities.
- B. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- C. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- D. Excavate for and remove underground utilities indicated to be removed.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Grind down stumps and remove roots larger than 2 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed subgrade.
 - 3. Use only hand methods or air spade for grubbing within protection zones.
 - 4. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
 - 1. Limit height of topsoil stockpiles to 72 inches.
 - 2. Do not stockpile topsoil within protection zones.
 - 3. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

- B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 1000

SECTION 31 2000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Geotextiles.
 - 2. Controlled low-strength material.
 - 3. Geofoam.
 - 4. Warning tape.
- B. Related Requirements:
 - 1. Section 31 1000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
 - 2. Section 32 9200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.

1.2 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, will be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.

- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other fabricated stationary features constructed above or below the ground surface.
- I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct preexcavation conference at Project site.
 - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D2487.
 - 2. Laboratory compaction curve according to ASTM D698.
- C. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.6 QUALITY ASSURANCE

- A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E329 and ASTM D3740 for testing indicated.

1.7 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures are in place.
- C. Do not commence earth-moving operations until plant-protection measures specified in Section 01 5639 "Temporary Tree and Plant Protection" are in place.
- D. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- E. Do not direct vehicle or equipment exhaust towards protection zones.
- F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS**2.1 SOIL MATERIALS**

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.
 - 1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.
- H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.
- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.
- J. Sand: ASTM C33/C33M; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Self-compacting, cellular, low-density, flowable concrete material produced from the following:
 - 1. Portland Cement: ASTM C150/C150M, Type I.
 - 2. Fly Ash: ASTM C618, Class C or F.
 - 3. Normal-Weight Aggregate: ASTM C33/C33M, 3/4-inch nominal maximum aggregate size.
 - 4. Foaming Agent: ASTM C869/C869M.
 - 5. Water: ASTM C94/C94M.

2.4 GEOFOAM

- A. Extruded-Polystyrene Board Insulation: ASTM C578, Type IV, 1.55-lb/cu. ft. density, 25-psi compressive strength.
- B. Molded-Polystyrene Board Insulation: ASTM C578, Type I, 0.90-lb/cu. ft. density, 10-psi compressive strength.
- C. Rigid Cellular Polystyrene Geofoam: ASTM D6817, Type EPS 19, 1.15-lb/cu. ft. density, 5.8-psi compressive strength at 1 percent deformation; 16-psi compressive strength at 10 percent deformation.
- D. Connectors: Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors.

2.5 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.
- B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.

PART 3 - EXECUTION**3.1 PREPARATION**

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
- B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
- D. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

3.3 EXPLOSIVES

- A. Explosives:
 - 1. Do not use explosives.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
 - 1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
 - 2. Cut and protect roots according to requirements in Section 01 5639 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
 - 1. Clearance: 12 inches each side of pipe or conduit.
- C. Trench Bottoms:
 - 1. Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
 - a. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.8 SUBGRADE INSPECTION

- A. Notify Architect when excavations have reached required subgrade.
- B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below pavements to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit price changes in the Work.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Surveying locations of underground utilities for Record Documents.
 - 2. Testing and inspecting underground utilities.
 - 3. Removing concrete formwork.
 - 4. Removing trash and debris.
 - 5. Removing temporary shoring, bracing, and sheeting.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Initial Backfill:
 - 1. Soil Backfill: Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
 - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- E. Final Backfill:
 - 1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.
 - 2. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
- F. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements.

3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use satisfactory soil material.
 - 2. Under walks and pavements, use satisfactory soil material.
 - 3. Under steps and ramps, use engineered fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.13 GEOFOAM FILL

- A. Place a leveling course of sand, 2 inches thick, over subgrade. Finish leveling course to a tolerance of 1/2 inch when tested with a 10-foot straightedge.
 - 1. Place leveling course on subgrades free of mud, frost, snow, or ice.
- B. Install geofoam blocks in layers with abutting edges and ends and with the long dimension of each block at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.
- C. Install geofoam connectors at each layer of geofoam to resist horizontal displacement according to geofoam manufacturer's written instructions.
- D. Cover geofoam with subdrainage geotextile before placing overlying soil materials.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D698:
1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.
 3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
 4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
1. Turf or Unpaved Areas: Plus or minus 1 inch.
 2. Walks: Plus or minus 1 inch.
 3. Pavements: Plus or minus 1/2 inch.

3.17 SUBSURFACE DRAINAGE

- A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D698.
- B. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.
1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D698.
 2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
 - 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place base course material over subbase course under hot-mix asphalt pavement.
 - 3. Shape subbase course and base course to required crown elevations and cross-slope grades.
 - 4. Place subbase course and base course 6 inches or less in compacted thickness in a single layer.
 - 5. Place subbase course and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 - 6. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.19 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- C. Testing agency will test compaction of soils in place according to ASTM D1556, ASTM D2167, ASTM D2937, and ASTM D6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area but in no case fewer than three tests.
 - 2. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.
- D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.
 - 1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 2000

SECTION 32 1216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hot-mix asphalt paving.
 - 2. Cold milling of existing asphalt pavement.
- B. Related Requirements:
 - 1. Section 02 4119 "Selective Demolition" for HMA pavement removal.
 - 2. Section 31 2000 "Earth Moving" for subgrade preparation, fill material, separation geotextiles, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
 - a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
 - b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.

1.3 ACTION SUBMITTALS

- A. Hot-Mix Asphalt Designs:
 - 1. For each hot-mix asphalt design proposed for the Work.
- B. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For paving-mix manufacturer and testing agency.
- B. Material Certificates: Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.
 - 1. Aggregates.
 - 2. Asphalt binder.
 - 3. Asphalt cement.
 - 4. Tack coat.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.
- B. Testing Agency Qualifications: Qualified in accordance with ASTM D3666 for testing indicated.
- C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Michigan Department of Transportation (MDOT) for asphalt paving work.
 - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 FIELD CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
 - 1. Tack Coat: Minimum surface temperature of 60 deg F.
 - 2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 3. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.

PART 2 - PRODUCTS**2.1 AGGREGATES**

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Coarse Aggregate: ASTM D692/D692M, sound; angular crushed stone or crushed gravel.
- C. Fine Aggregate: ASTM D1073, sharp-edged natural sand or sand prepared from stone, gravel, or combinations thereof.
 - 1. For hot-mix asphalt, limit natural sand to a maximum of 10 percent by weight of the total aggregate mass.
- D. Mineral Filler: ASTM D242/D242M, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: ASTM D6373 binder designation PG 58-28.
- B. Asphalt Cement: ASTM D3381/D3381M for viscosity-graded material.

- C. Tack Coat: ASTM D977 emulsified asphalt, or ASTM D2397/D2397M cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- D. Water: Potable.

2.3 AUXILIARY MATERIALS

- A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires, asphalt shingles, or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

2.4 MIXES

- A. Recycled Content of Hot-Mix Asphalt: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 10 percent or more than 15 percent by weight.
- B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes; designed in accordance with procedures in AI MS-2, "Asphalt Mix Design Methods"; and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Base Course: Refer to plans.
 - 3. Surface Course: Refer to plans.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protection: Provide protective materials, procedures, and worker training to prevent asphalt materials from spilling, coating, or building up on curbs, driveway aprons, manholes, and other surfaces adjacent to the Work.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 - 2. Proof-roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons.

3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.3 COLD MILLING

- A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
 1. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
 2. Control rate of milling to prevent tearing of existing asphalt course.
 3. Repair or replace curbs, driveway aprons, manholes, and other construction damaged during cold milling.
 4. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
 5. Patch surface depressions deeper than 1 inch after milling, before wearing course is laid.
 6. Handle milled asphalt material in accordance with approved waste management plan.
 7. Keep milled pavement surface free of loose material and dust.
 8. Do not allow milled materials to accumulate on-site.

3.4 SURFACE PREPARATION

- A. Ensure that prepared subgrade has been proof-rolled and is ready to receive paving. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces.
- B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.
 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 HOT-MIX ASPHALT PLACEMENT

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
 2. Place hot-mix asphalt surface course in single lift.
 3. Spread mix at a minimum temperature of 250 deg F.
 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.
 - 2. Complete a section of asphalt base course before placing asphalt surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat to joints.
 - 2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
 - 3. Offset transverse joints, in successive courses, a minimum of 24 inches.
 - 4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method in accordance with AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
 - 5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
 - 6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.7 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density, Marshall Test Method: 96 percent of reference laboratory density in accordance with ASTM D6927, but not less than 94 percent or greater than 100 percent.

2. Average Density, Rice Test Method: 92 percent of reference maximum theoretical density in accordance with ASTM D2041/D2041M, but not less than 90 percent or greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce thickness indicated within the following tolerances:
 1. Base Course: Plus or minus 1/2 inch.
 2. Surface Course: Plus 1/4 inch, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 1. Base Course: 1/4 inch.
 2. Surface Course: 1/8 inch.
 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined in accordance with ASTM D3549/D3549M.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement in accordance with ASTM D979/D979M.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared in accordance with ASTM D2041/D2041M, and compacted in accordance with job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples in accordance with ASTM D1188 or ASTM D2726/D2726M.
 - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
 - b. Field density of in-place compacted pavement may also be determined by nuclear method in accordance with ASTM D2950/D2950M and coordinated with ASTM D1188 or ASTM D2726/D2726M.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.10 WASTE HANDLING

- A. General: Handle asphalt-paving waste in accordance with approved waste management plan.

END OF SECTION 32 1216

SECTION 32 1313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes concrete paving including the following:
 - 1. Walks.
- B. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for general building applications of concrete.
 - 2. Section 32 1373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.
 - b. Quality control of concrete materials and concrete paving construction practices.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified ready-mix concrete manufacturer.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Fiber reinforcement.
 - 3. Admixtures.
 - 4. Curing compounds.

5. Joint fillers.

C. Material Test Reports: For each of the following:

1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.

1. Personnel conducting field tests must be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.8 FIELD CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:

1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

- C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with ACI 301 unless otherwise indicated.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 CONCRETE MATERIALS

- A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:
1. Portland Cement: ASTM C150/C150M, gray portland cement Type I.
 2. Fly Ash: ASTM C618, Class C or Class F.
 3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
 4. Blended Hydraulic Cement: ASTM C595/C595M, Type IS, portland blast-furnace slag cement.
- B. Normal-Weight Aggregates: ASTM C33/C33M, Class 4M, uniformly graded. Provide aggregates from a single source.
1. Maximum Coarse-Aggregate Size: 3/4 inch nominal.
 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Air-Entraining Admixture: ASTM C260/C260M.
- D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
1. Water-Reducing Admixture: ASTM C494/C494M, Type A.

2. Retarding Admixture: ASTM C494/C494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

E. Water: Potable and complying with ASTM C94/C94M.

2.4 FIBER REINFORCEMENT

- A. Synthetic Fiber, Monofilament Fibers: Monofilament polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches long.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
 - b. FORTA Corporation
 - c. FullForce by ABC Polymer Industries, LLC
 - d. GCP Applied Technologies Inc.
 - e. Nycon Corporation
 - f. Propex Operating Company, LLC
 - g. Sika Corporation
- B. Synthetic Fiber, Fibrillated Fibers: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches long.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
 - b. FORTA Corporation
 - c. FullForce by ABC Polymer Industries, LLC
 - d. GCP Applied Technologies Inc.
 - e. Nycon Corporation
 - f. Propex Operating Company, LLC
 - g. Sika Corporation

2.5 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.

- D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Bon Tool Co.
 - b. Brickform; a division of Solomon Colors
 - c. ChemMasters, Inc
 - d. Dayton Superior Corporation
 - e. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
 - f. Kaufman Products, Inc
 - g. Lambert Corporation
 - h. Laticrete International, Inc.
 - i. Master Builders Solutions
 - j. Metalcrete Industries
 - k. Nox-Crete Products Group
 - l. Sika Corporation
 - m. SpecChem, LLC
 - n. TK Products Construction Coatings, a Fenix Group SPC Company
 - o. Vexcon Chemicals Inc.
 - p. W. R. Meadows, Inc
- E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anti-Hydro International, Inc
 - b. ChemMasters, Inc
 - c. Dayton Superior Corporation
 - d. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
 - e. Kaufman Products, Inc
 - f. Lambert Corporation
 - g. Laticrete International, Inc.
 - h. Nox-Crete Products Group
 - i. Right Pointe
 - j. SpecChem, LLC
 - k. TK Products Construction Coatings, a Fenix Group SPC Company
 - l. Unitex; a Brand of Dayton Superior Corporation
 - m. Vexcon Chemicals Inc.
 - n. W. R. Meadows, Inc
- F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 2, Class B, dissipating.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anti-Hydro International, Inc
 - b. ChemMasters, Inc

- c. Dayton Superior Corporation
- d. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
- e. Kaufman Products, Inc
- f. Lambert Corporation
- g. Laticrete International, Inc.
- h. SpecChem, LLC
- i. Vexcon Chemicals Inc.
- j. W. R. Meadows, Inc

2.6 RELATED MATERIALS

- A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber in preformed strips.

2.7 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
 - 2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.
- B. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - 1. Air Content, 1-1/2-inch Nominal Maximum Aggregate Size: 5-1/2 percent plus or minus 1-1/2 percent.
 - 2. Air Content, 1-inch Nominal Maximum Aggregate Size: 6 percent plus or minus 1-1/2 percent.
 - 3. Air Content, 3/4-inch Nominal Maximum Aggregate Size: 6 percent plus or minus 1-1/2 percent.
- D. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use water-reducing admixture in concrete as required for placement and workability.
 - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- F. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd.
- G. Concrete Mixtures: Normal-weight concrete.
 - 1. Compressive Strength (28 Days): 4000 psi.

2. Maximum W/C Ratio at Point of Placement: 0.45.
3. Slump Limit: 5 inches, plus or minus 1 inch.

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Work.
 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.
 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
 2. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 31 2000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Provide tie bars at sides of paving strips where indicated.
 - 3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
 - 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 1/4-inch radius.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

- E. Edging: After initial floating, tool edges of paving and joints in concrete with an edging tool to a 1/4-inch radius.

3.5 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from side forms. Use only square-faced shovels for hand spreading and consolidation.
- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- J. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.6 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.

- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
 - 1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

3.7 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by curing compound as follows:
 - 1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.8 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
 - 1. Elevation: 3/4 inch.
 - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3. Surface: Gap below 10-feet- long; unleveled straightedge not to exceed 1/2 inch.
 - 4. Joint Spacing: 3 inches.
 - 5. Contraction Joint Depth: Plus 1/4 inch, no minus.
 - 6. Joint Width: Plus 1/8 inch, no minus.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

- B. Testing Services: Testing and inspecting of composite samples of fresh concrete obtained according to ASTM C172/C172M will be performed according to the following requirements:
1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing to be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C143/C143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C231/C231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
 5. Compression Test Specimens: ASTM C31/C31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 6. Compressive-Strength Tests: ASTM C39/C39M; test one specimen at seven days and two specimens at 28 days.
 - a. A compressive-strength test to be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results to be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests to contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency will make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Concrete paving will be considered defective if it does not pass tests and inspections.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

- I. Prepare test and inspection reports.

3.10 REPAIR AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 32 1313

SECTION 32 1373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cold-applied joint sealants.
 - 2. Hot-applied joint sealants.
 - 3. Cold-applied, fuel-resistant joint sealants.
 - 4. Hot-applied, fuel-resistant joint sealants.
 - 5. Joint-sealant backer materials.
 - 6. Primers.
- B. Related Requirements:
 - 1. Section 07 9200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Concrete pavement joint sealants.
 - 2. Joint-sealant backer materials.

1.3 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Installers: Entity that employs installers and supervisors who are trained and approved by manufacturer.

1.4 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
 - 2. When joint substrates are wet.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain joint sealants from single manufacturer for each sealant type.

2.2 JOINT SEALANTS, GENERAL

- A. Compatibility: Provide joint sealants, backer materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.3 COLD-APPLIED JOINT SEALANTS

- A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D5893/D5893M, Type NS.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; RoadSaver Silicone.
 - b. Pecora Corporation; 301 NS.
 - c. The Dow Chemical Company; Dow Corning 888 Silicone Joint Sealant.
- B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D5893/D5893M, Type SL.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; RoadSaver Silicone SL.
 - b. Pecora Corporation; 300 SL.
 - c. The Dow Chemical Company; Dow Corning 890-SL Silicone Joint Sealant.
- C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade NS, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. W.R. Meadows, Inc; Pourthane NS.
- D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. W.R. Meadows, Inc; Pourthane SL.
- E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Pecora Corporation; Dynatred.

2.4 HOT-APPLIED JOINT SEALANTS

- A. Hot-Applied, Single-Component Joint Sealant, Type I: ASTM D6690.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; Asphalt Rubber Plus.
 - b. Right Pointe; JTS Asphalt Rubber Modified 043.
 - c. W.R. Meadows, Inc; Sealtight 1190.
- B. Hot-Applied, Single-Component Joint Sealant, Type I or Type II: ASTM D6690.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; RoadSaver 201.
 - b. Right Pointe; JTS 3405 Parking Lot Sealant 007.

- C. Hot-Applied, Single-Component Joint Sealant, Type I, II, or III: ASTM D6690.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; RoadSaver 222.
 - b. Right Pointe; JTS 3405 Regular 003.
 - c. W.R. Meadows, Inc; Sealtight 3405.
- D. Hot-Applied, Single-Component Joint Sealant, Type IV: ASTM D6690.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Crafcro Inc.; RoadSaver 231.
 - b. W.R. Meadows, Inc; Sealtight 3405M.

2.5 COLD-APPLIED, FUEL-RESISTANT JOINT SEALANTS

- A. Fuel-Resistant, Single-Component, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. BASF Corporation; MasterSeal CR 125 (Pre-2014: Sonomeric 1).
- B. Fuel-Resistant, Multicomponent, Pourable, Modified-Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 12-1/2 or 25, for Use T.
 - 1. Products: Subject to compliance with requirements, provide a product by one of the following manufacturers:
 - a. Pecora Corporation
 - b. W.R. Meadows, Inc

2.6 HOT-APPLIED, FUEL-RESISTANT JOINT SEALANTS

- A. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants, Type I or Type II: ASTM D7116.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Crafcro Inc.; Superseal 1614A.
- B. Hot-Applied, Fuel-Resistant, Single-Component Joint Sealants, Type III: ASTM D7116.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Crafcro Inc.; Superseal Low-Mod.

2.7 JOINT-SEALANT BACKER MATERIALS

- A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.
- B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.
- C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

- D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.8 PRIMERS

- A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.
 - 1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
- B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

- A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.
- C. Install joint-sealant backers to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of joint-sealant backer materials.
 - 2. Do not stretch, twist, puncture, or tear joint-sealant backer materials.
 - 3. Remove absorbent joint-sealant backer materials that have become wet before sealant application and replace them with dry materials.

- D. Install joint sealants immediately following backer material installation, using proven techniques that comply with the following:
 - 1. Place joint sealants so they fully contact joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants in accordance with the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
 - 1. Remove excess joint sealant from surfaces adjacent to joints.
 - 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

- A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.
- B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

END OF SECTION 32 1373

PLAYGROUND EQUIPMENT**SECTION 32 1816.15 - FREESTANDING PLAY EVENTS****PART 1 - GENERAL****1.1 SUMMARY**

- A. ~~Freestanding play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com, shall adhere to the following specifications:~~
1. ~~Molded Polyethylene – Products are to be rotationally molded plastic with a ¼" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive and be available in any of the manufacturer's standard colors.~~
 2. ~~High Density Polyethylene shall be made from either ½" or ¾" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.~~
 3. ~~Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.~~
 4. ~~Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate topcoat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing. PowerScape Plus stainless-steel fasteners shall be button pin-in head, socket cap screws with a two-part epoxy locking patch added to the threads. The two-part locking patch shall consist of one part resin and one part catalyst which are activated during installation. After curing, the material shall require a minimum of five times the installation torque to remove the fastener. Manufacturer shall provide special installation tools for pinned fasteners.~~

1.2 FINISHES

- A. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.

2.3 EXECUTION**A. INSTALLATION**

1. General – Comply with manufacturer's written installation instructions.
2. Uprights – Set posts in concrete footings. Protect finish during installation. Comply with locations, height, and plumb requirements.

B. FIELD QUALITY CONTROL

1. Installation shall be performed by factory certified technicians with at least 3 years' experience installing playground equipment

C. COMPLETION

1. Protect installed products until completion of project.
2. Touch up, repair, or replace damaged products before substantial completion.
3. Installer shall turn over all installation instructions, parts lists, maintenance instructions, tool kits, and spare materials to the owner upon completion.

PART 3 - MODERN CITY PLAY SYSTEMS*PLAYGROUNDS EQUIPMENT***1.1 GENERAL****A. SUMMARY**

1. Section includes composite structure, stand-alone play events and accessories.
2. Basis of design is Modern City® modular play structures, free-standing play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com.

*for new playgrounds as indicated for example***B. SUBMITTALS**

1. Product Data: Include physical characteristics such as shape, dimensions, gauge and material for each component. Provide finish information and available colors.
2. Shop Drawings: Include plans, elevations, details, and installation instructions for each component.
3. Warranty: Include sample of manufacturer's standard warranty.

C. QUALITY ASSURANCE

1. Manufacturer Qualifications: Equipment components shall be certified by IPEMA's third party product certification service. Equipment and structural components shall bear the IPEMA certification seal. IPEMA validation is available at www.ipema.org.
2. Installer: Must be certified by the manufacturer.
3. Safety Standards: Comply with requirements of ASTM F 1487.

D. WARRANTY

1. Warranty shall meet or exceed the warranty provisions of GameTime as follows:
 - a. Lifetime limited warranty on PowerScape®, PrimeTime®, Modern City®, Xscape® & IONiX® uprights.
 - b. Lifetime limited warranty on Tru-Loc® connections and upright bolt-through connections.
 - c. Lifetime limited warranty on all hardware.

- d. 20-Year limited warranty on Timber Décor™ & Timbers recycled plastic lumber.
- e. 15-Year limited warranty on metal decks, pipes, rungs, rails, loops, braces, and footbucks.
- f. 15-Year limited warranty on rotationally molded products.
- g. 15-Year limited warranty on VistaRope nylon bearings and ring junction pieces.
- h. 10-Year limited warranty on GTFit, THRIVE and Challenge Course posts & bars.
- i. 10-Year limited warranty on site furnishings against structural failure.
- j. 10-Year limited warranty on SunBlox® products.
- k. 10-Year limited warranty on integrated GTShade® products.
- l. 10-Year limited warranty on fiberglass and DHPL signage.
- m. 10-Year limited warranty on VistaRope WeaveTech cables.
- n. 5-Year limited warranty on TuffForms® structures, including TuffCrete™ and PolyShield.
- o. 5-Year limited warranty on nylon covered cable net climbers and components.
- p. 5-Year limited warranty on GT Symphony Freenotes™ Harmony Park components.
- q. 5-Year limited warranty on Super Seats™.
- r. 5-Year limited warranty on premature wear of VistaRope cables.
- s. 3-Year limited warranty on Everybody Plays polyurea coated foam & rubber strips.
- t. 3-Year limited warranty on SaddleMates® rubber and “C” springs.
- u. 3-Year limited warranty on SureGrip Material
- v. 2-Year limited warranty on Challenge Course timing components.
- w. 1-Year limited warranty on all other GameTime products.

1.2
3.2

PRODUCTS

A. MATERIALS

1. Main Structural Uprights shall be fabricated from 5" x 5" x .120" (11 Gauge) wall 1/4" hot rolled steel plate. Upright insert assemblies shall be all weld assemblies and shall be coated after fabrication with a custom formula of TGIC polyester powder coating in conformance with the specifications outlined herein
2. Component Attachments – Must be factory preset to the uprights to ensure full field compliance with current safety standards. Hinged, or any clamps, that require field locating or field drilling or installation are not acceptable, due to the susceptibility of installation out of compliance with safety standards.
3. Plastisol Coated Steel – Products including decks, platforms, steps, and bridges shall be fabricated from 11-gauge perforated steel with a .08" minimum thickness, textured slip-resistant polyvinyl chloride plastisol dipped coating. Decks must attach directly to threaded inserts factory installed to uprights, using (2) 3/8" bolts at each upright connection point to eliminate the possibility of deck slipping. Plastisol coating must be free of latex and tested to meet California standards for phthalate levels and safe for children.

4. Molded Polyethylene – Products are to be rotationally molded plastic with a ¼" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive and be available in any of the manufacturer's standard colors.
5. High Density Polyethylene shall be made from either ½" or ¾" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.
6. Metal Climbers and Enclosures – Products shall be fabricated from 1 5/16" OD x .083" (14 gauge) wall galvanized steel tubing with vertical members fabricated of 1 1/16" OD x .075 (15 gauge) wall galvanized steel tubing. All tubing used shall be an electrical resistance welded, cold rolled, high strength steel tubing. The exterior coating will consist of an In-line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion, and acrylic over-coating. The interior coating will consist of a special organic acrylic modified polyester.
7. Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.
8. Wire Mesh shall be fabricated from .306" Steel Wire. Wire Mesh Welded Panels shall be an all-weld assembly and shall be coated after fabrication with a custom formula of TGIC polyester powder coating in conformance with the specifications outlined herein.
9. Chain assembly shall be 4/0 straight link coil stainless steel chain, cut to length.
10. Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate topcoat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing. PowerScape Plus stainless-steel fasteners shall be button pin-in head, socket cap screws with a two-part epoxy locking patch added to the threads. The two-part locking patch shall consist of one part resin and one part catalyst which are activated during installation. After curing, the material shall require a minimum of five times the installation torque to remove the fastener. Manufacturer shall provide special installation tools for pinned fasteners.

B. REQUIRED COMPONENTS

1. In addition to the requirements contained in this section, refer to layout drawings and schedules of components and accessories on drawings.
2. All components, accessories, hardware, and other items required for a complete and usable system shall be provided.

C. FINISHES

1. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.
2. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

1.3
3.3**EXECUTION****A. INSTALLATION**

1. General – Comply with manufacturer's written installation instructions.
2. Uprights – Set posts in concrete footings. Protect finish during installation. Comply with locations, height, and plumb requirements.

B. FIELD QUALITY CONTROL

1. Installation shall be performed by factory certified technicians with at least 3 years experience installing playground equipment

C. COMPLETION

1. Protect installed products until completion of project.
2. Touch up, repair, or replace damaged products before substantial completion.
3. Installer shall turn over all installation instructions, parts lists, maintenance instructions, tool kits, and spare materials to the owner upon completion.

PART 4 - POWERSCAPE PLAYGROUND SYSTEM**4.1 GENERAL****A. SUMMARY**

1. Section includes composite structure, stand-alone play events and accessories.
2. Basis of design is PowerScape® modular play structures, free-standing play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com.

B. SUBMITTALS

1. Product Data: Include physical characteristics such as shape, dimensions, gauge and material for each component. Provide finish information and available colors.
2. Shop Drawings: Include plans, elevations, details, and installation instructions for each component.
3. Warranty: Include sample of manufacturer's standard warranty.

(5)

PART 7 - ALGER PLAYGROUND EQUIPMENT

7.1 GENERAL

- A. GRPS is requesting designs for new playground equipment and surfacing for Alger Elementary's Playground. There are two playgrounds, one for 5-12 year olds and a separate playground for 2-5 year olds. (2) options
- B. The Basis of Design is GameTime playground equipment, represented by Sinclair Recreation. Comparable products and designs will be accepted by GRPS, provided the designs provide equal or greater quality and play value. Grand Rapids Public Schools and their representatives will be the sole deciding factor in determining if alternate products and designs are equal.
- C. All equipment must be ASTM, CPSC and ADA compliant. Equipment manufacturers must be in good standing with IPEMA and carry a minimum of \$20 Million in Product liability insurance.

7.2 DESIGN CRITERIA

- A. Alger 5-12 Playground
 - 1. Child Capacity range: 200-230
 - 2. Total Play Events: Minimum of 60
 - 3. Please include the following in your playground design:
 - a. Five bay swing with a minimum 3 1/2" OD toprail and frame
 - b. One ADA swing seat
 - c. Five belt seats
 - d. Between 10 – 14 swinging opportunities
 - e. Multi-user swing (saucer swing)
 - f. Two spinning elements
 - g. Two freestanding climbers for imaginative play
 - h. Three benches with backs
 - i. One communication panel
 - j. One modular structure with a minimum of 3 1/2" uprights
 - 1) Maximum height of 8'
 - 2) Between 3-5 decks
 - 3) Roofs
 - 4) 1 – 3 slides
 - 5) Bridges
 - 6) Durable climbers
 - 7) Balancing activities
 - 8) Panels
 - 9) Upper Body activities
- B. Alger 2-5 Playground:
 - 1. Child Capacity range: 80-100
 - 2. Total Play Events: Minimum of 28
 - 3. Please include the following in your playground design:
 - a. Three bay swing with a minimum 3 1/2" OD toprail and frame
 - b. One ADA swing seat

- c. Five belt seats
- d. Saucer Swing
- e. Inclusive whirl for wheelchair use
- f. Freestanding Climber or playhouse
- g. Sensor Wall with unique activities
- h. Musical panels
- i. Three benches with backs
- j. Communication Panel
- k. One modular structure with a minimum of 3 ½" uprights
 - 1) Maximum height of 5'
 - 2) Between 2-4 decks
 - 3) Roofs
 - 4) 1 – 3 slides
 - 5) Bridge or climber links
 - 6) Balancing activity
 - 7) Durable climbers

END OF SECTION 32 1816.15

- B. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

PART 2 - IONIX PLAY SYSTEMS

2.1 GENERAL

A. SUMMARY

1. Section includes composite structure, stand-alone play events and accessories.
2. Basis of design is Ionix® modular play structures, free-standing play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com.

B. SUBMITTALS

1. Product Data: Include physical characteristics such as shape, dimensions, gauge and material for each component. Provide finish information and available colors.
2. Shop Drawings: Include plans, elevations, details, and installation instructions for each component.
3. Warranty: Include sample of manufacturer's standard warranty.

C. QUALITY ASSURANCE

1. Manufacturer Qualifications: Equipment components shall be certified by IPEMA's third party product certification service. Equipment and structural components shall bear the IPEMA certification seal. IPEMA validation is available at www.ipema.org.
2. Installer: Must be certified by the manufacturer.
3. Safety Standards: Comply with requirements of ASTM F 1487.

D. WARRANTY

1. Warranty shall meet or exceed the warranty provisions of GameTime as follows:
 - a. Lifetime limited warranty on PowerScape®, PrimeTime®, Modern City®, Xscape® & IONiX® uprights.
 - b. Lifetime limited warranty on Tru-Loc® connections and upright bolt-through connections.
 - c. Lifetime limited warranty on all hardware.
 - d. 20-Year limited warranty on Timber Décor™ & Timbers recycled plastic lumber.
 - e. 15-Year limited warranty on metal decks, pipes, rungs, rails, loops, braces, and footbucks.
 - f. 15-Year limited warranty on rotationally molded products.
 - g. 15-Year limited warranty on VistaRope nylon bearings and ring junction pieces.
 - h. 10-Year limited warranty on GTFit, THRIVE and Challenge Course posts & bars.
 - i. 10-Year limited warranty on site furnishings against structural failure.
 - j. 10-Year limited warranty on SunBlox® products.
 - k. 10-Year limited warranty on integrated GTShade® products.

- l. 10-Year limited warranty on fiberglass and DHPL signage.
- m. 10-Year limited warranty on VistaRope WeaveTech cables.
- n. 5-Year limited warranty on TuffForms® structures, including TuffCrete™ and PolyShield.
- o. 5-Year limited warranty on nylon covered cable net climbers and components.
- p. 5-Year limited warranty on GT Symphony Freenotes™ Harmony Park components.
- q. 5-Year limited warranty on Super Seats™.
- r. 5-Year limited warranty on premature wear of VistaRope cables.
- s. 3-Year limited warranty on Everybody Plays polyurea coated foam & rubber strips.
- t. 3-Year limited warranty on SaddleMates® rubber and "C" springs.
- u. 3-Year limited warranty on SureGrip Material
- v. 2-Year limited warranty on Challenge Course timing components.
- w. 1-Year limited warranty on all other GameTime products.

2.2 PRODUCTS

A. MATERIALS

1. Main Structural Uprights
 - a. Shall be 3.5" outside diameter, 13 gauge (nominal .095") galvanized round tubing, manufactured to ASTM A-500 Grade B tolerances from cold-formed steel conforming to ASTM A-1011 Sheet Spec for steel coil. Minimum yield strength shall be 45,000 psi and minimum tensile strength shall be 48,000 psi. The exterior surface is In line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion coated, and a clear high performance organic polymer is applied. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 91% minimum zinc dust content in organic resin, as per ASTM F-1043. All upright posts shall be coated with a custom formula TGIC.
2. Component Attachment – Must be factory preset to the uprights to ensure full field compliance with current safety standards. Hinges, or any clamps, that require field locating or field drilling or installation are not acceptable, due to the susceptibility of installation out of compliance with safety standards.
3. Plastisol Coated Steel – Products including platforms, steps, and bridges shall be fabricated from 12-gauge perforated steel with a .08" minimum thickness, textured slip-resistant polyvinyl chloride plastisol dipped coating. Platforms must attach directly to threaded inserts factory installed to uprights, using (2) 3/8" bolts at each upright connection point to eliminate the possibility of deck slipping. Plastisol coating shall be free of latex and tested to meet California standards for phthalate levels and safe for children. Available in manufacturers standard colors.
4. Molded Polyethylene – Products are to be rotationally molded plastic with a 1/4" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive and be available in any of the manufacturer's standard colors.

5. High Density Polyethylene shall be made from either ½" or ¾" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.
6. Metal Climbers and Enclosures – Products shall be fabricated from 1 5/16" OD x .083" (14 gauge) wall galvanized steel tubing with frames fabricated of 2 3/8" OD x .134 (10 gauge) wall galvanized steel tubing. All tubing used shall be an electrical resistance welded, cold rolled, high strength steel tubing. The exterior coating will consist of an in-line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion, and acrylic over-coating. The interior coating will consist of a special organic acrylic modified polyester. All climbers shall be coated with a custom formula TGIC.
7. Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.
8. Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate topcoat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing.

B. REQUIRED COMPONENTS

1. In addition to the requirements contained in this section, refer to layout drawings and schedules of components and accessories on drawings.
2. All components, accessories, hardware, and other items required for a complete and usable system shall be provided.

C. FINISHES

1. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.
2. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

C. QUALITY ASSURANCE

1. Manufacturer Qualifications: Equipment components shall be certified by IPEMA's third party product certification service. Equipment and structural components shall bear the IPEMA certification seal. IPEMA validation is available at www.ipema.org.
2. Installer: Must be certified by the manufacturer.
3. Safety Standards: Comply with requirements of ASTM F 1487.

D. WARRANTY

1. Warranty shall meet or exceed the warranty provisions of GameTime as follows:
 - a. Lifetime limited warranty on PowerScape®, PrimeTime®, Modern City®, Xscape® & IONiX® uprights.
 - b. Lifetime limited warranty on Tru-Loc® connections and upright bolt-through connections.
 - c. Lifetime limited warranty on all hardware.
 - d. 20-Year limited warranty on Timber Décor™ & Timbers recycled plastic lumber.
 - e. 15-Year limited warranty on metal decks, pipes, rungs, rails, loops, braces, and footbucks.
 - f. 15-Year limited warranty on rotationally molded products.
 - g. 15-Year limited warranty on VistaRope nylon bearings and ring junction pieces.
 - h. 10-Year limited warranty on GTFit, THRIVE and Challenge Course posts & bars.
 - i. 10-Year limited warranty on site furnishings against structural failure.
 - j. 10-Year limited warranty on SunBlox® products.
 - k. 10-Year limited warranty on integrated GTShade® products.
 - l. 10-Year limited warranty on fiberglass and DHPL signage.
 - m. 10-Year limited warranty on VistaRope WeaveTech cables.
 - n. 5-Year limited warranty on TuffForms® structures, including TuffCrete™ and PolyShield.
 - o. 5-Year limited warranty on nylon covered cable net climbers and components.
 - p. 5-Year limited warranty on GT Symphony Freenotes™ Harmony Park components.
 - q. 5-Year limited warranty on Super Seats™.
 - r. 5-Year limited warranty on premature wear of VistaRope cables.
 - s. 3-Year limited warranty on Everybody Plays polyurea coated foam & rubber strips.
 - t. 3-Year limited warranty on SaddleMates® rubber and "C" springs.
 - u. 3-Year limited warranty on SureGrip Material
 - v. 2-Year limited warranty on Challenge Course timing components.
 - w. 1-Year limited warranty on all other GameTime products.

4.2 PRODUCTS

A. MATERIALS

1. Main Structural Uprights
 - a. Shall be 5" outside diameter tubing, 1/8" wall thickness, extruded from 6005A-T61 aluminum alloy conforming to ASTM-B-221. Minimum yield strength shall be 35,000 psi and minimum tensile strength shall be 38,000 psi. All upright posts shall be coated with a custom formula TGIC polyester powder coating in conformance with the specification outlined herein.
 - b. Shall be 5" outside diameter, 11 gauge (nominal .120") galvanized round tubing, manufactured to ASTM A-1011 Grade B tolerances from cold-formed steel conforming to ASTM A-569 Sheet Spec for steel coil. Minimum yield strength shall be 45,000 psi and minimum tensile strength shall be 48,000 psi. The exterior surface is In line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion coated, and a clear high performance organic polymer is applied. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 91% minimum zinc dust content in organic resin, as per ASTM F-1043. All upright posts shall be coated with a custom formula TGIC.
2. Tru Loc Connectors – Must attach directly to factory preset threaded insert in the uprights to ensure full field compliance with current safety standards. Hinged, or any clamps, that require field locating or field drilling or installation are not acceptable, due to the susceptibility of installation out of compliance with safety standards.
3. Plastisol Coated Steel – Products including decks, platforms, steps, and bridges shall be fabricated from 11-gauge perforated steel with a .08" minimum thickness, textured slip-resistant polyvinyl chloride plastisol dipped coating. Square deck size must be at least 49" x 49" (2,401 square inches), and triangular decks must be equally 49" on all sides (1,040 square inches) and bolt through the uprights. Decks must attach directly to threaded inserts factory installed to uprights, using (2) 3/8" bolts at each upright connection point to eliminate the possibility of deck slipping. Plastisol coating must be free of latex and tested to meet California standards for phthalate levels and safe for children.
4. Molded Polyethylene – Products are to be rotationally molded plastic with a 1/4" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive and be available in any of the manufacturer's standard colors.
5. High Density Polyethylene shall be made from either 1/2" or 3/4" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.
6. Metal Climbers and Enclosures – Products shall be fabricated from 1 5/16" OD x .083" (14 gauge) wall galvanized steel tubing with vertical members fabricated of 1 1/16" OD x .075 (15 gauge) wall galvanized steel tubing. All tubing used shall be an electrical resistance welded, cold rolled, high strength steel tubing. The exterior coating will consist of an In-line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion, and acrylic over-coating. The interior coating will consist of a special organic acrylic modified polyester.

7. Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.
8. Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate topcoat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing. PowerScape Plus stainless-steel fasteners shall be button pin-in head, socket cap screws with a two-part epoxy locking patch added to the threads. The two-part locking patch shall consist of one part resin and one part catalyst which are activated during installation. After curing, the material shall require a minimum of five times the installation torque to remove the fastener. Manufacturer shall provide special installation tools for pinned fasteners.

B. REQUIRED COMPONENTS

1. In addition to the requirements contained in this section, refer to layout drawings and schedules of components and accessories on drawings.
2. All components, accessories, hardware, and other items required for a complete and usable system shall be provided.

C. FINISHES

1. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.
2. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

4.3 EXECUTION

A. INSTALLATION

1. General – Comply with manufacturer's written installation instructions.
2. Uprights – Set posts in concrete footings. Protect finish during installation. Comply with locations, height, and plumb requirements.

B. FIELD QUALITY CONTROL

1. Installation shall be performed by factory certified technicians with at least 3 years experience installing playground equipment

C. COMPLETION

1. Protect installed products until completion of project.
2. Touch up, repair, or replace damaged products before substantial completion.
3. Installer shall turn over all installation instructions, parts lists, maintenance instructions, tool kits, and spare materials to the owner upon completion.

PART 5 - PRIMETIME PLAYGROUND SYSTEM**5.1 GENERAL****A. SUMMARY**

1. Section includes composite structure, stand-alone play events and accessories.
2. Basis of design is PrimeTime® modular play structures, free-standing play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com.

B. SUBMITTALS

1. Product Data: Include physical characteristics such as shape, dimensions, gauge and material for each component. Provide finish information and available colors.
2. Shop Drawings: Include plans, elevations, details, and installation instructions for each component.
3. Warranty: Include sample of manufacturer's standard warranty.

C. QUALITY ASSURANCE

1. Manufacturer Qualifications: Equipment components shall be certified by IPEMA's third party product certification service. Equipment and structural components shall bear the IPEMA certification seal. IPEMA validation is available at www.ipema.org.
2. Installer: Must be certified by the manufacturer.
3. Safety Standards: Comply with requirements of ASTM F 1487.

D. WARRANTY

1. Warranty shall meet or exceed the warranty provisions of GameTime as follows:
 - a. Lifetime limited warranty on PowerScape®, PrimeTime®, Modern City®, Xscape® & IONiX® uprights.
 - b. Lifetime limited warranty on Tru-Loc® connections and upright bolt-through connections.
 - c. Lifetime limited warranty on all hardware.
 - d. 20-Year limited warranty on Timber Décor™ & Timbers recycled plastic lumber.
 - e. 15-Year limited warranty on metal decks, pipes, rungs, rails, loops, braces, and foot bucks.
 - f. 15-Year limited warranty on rotationally-molded products.
 - g. 15-Year limited warranty on VistaRope nylon bearings and ring junction pieces.

- h. 10-Year limited warranty on GTFit, THRIVE and Challenge Course posts & bars.
- i. 10-Year limited warranty on site furnishings against structural failure.
- j. 10-Year limited warranty on SunBlox® products.
- k. 10-Year limited warranty on integrated GTShade® products.
- l. 10-Year limited warranty on fiberglass and DHPL signage.
- m. 10-Year limited warranty on VistaRope WeaveTech cables.
- n. 5-Year limited warranty on TuffForms® structures, including TuffCrete™ and PolyShield.
- o. 5-Year limited warranty on nylon covered cable net climbers and components.
- p. 5-Year limited warranty on GT Symphony Freenotes™ Harmony Park components.
- q. 5-Year limited warranty on Super Seats™.
- r. 5-Year limited warranty on premature wear of VistaRope cables.
- s. 3-Year limited warranty on Everybody Plays polyurea coated foam & rubber strips.
- t. 3-Year limited warranty on SaddleMates® rubber and “C” springs.
- u. 3-Year limited warranty on SureGrip Material
- v. 2-Year limited warranty on Challenge Course timing components.
- w. 1-Year limited warranty on all other GameTime products.

5.2 PRODUCTS

A. MATERIALS

- 1. Main Structural Uprights
 - a. Shall be 3.5” outside diameter tubing, 1/8” wall thickness, extruded from 6005A-T61 aluminum alloy conforming to ASTM-B-221. Minimum yield strength shall be 35,000 psi and minimum tensile strength shall be 38,000 psi. All upright posts shall be coated with a custom formula TGIC polyester powder coating in conformance with the specification outlined herein.
 - b. Shall be 3.5” outside diameter, 13 gauge (nominal .095”) galvanized round tubing, manufactured to ASTM A-500 Grade B tolerances from cold-formed steel conforming to ASTM A-1011 Sheet Spec for steel coil. Minimum yield strength shall be 45,000 psi and minimum tensile strength shall be 48,000 psi. The exterior surface is In line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion coated, and a clear high performance organic polymer is applied. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 91% minimum zinc dust content in organic resin, as per ASTM F-1043. All upright posts shall be coated with a custom formula TGIC.
- 2. Component Attachment – Must be factory preset to the uprights to ensure full field compliance with current safety standards. Hinges, or any clamps, that require field locating or field drilling or installation are not acceptable, due to the susceptibility of installation out of compliance with safety standards.

3. Plastisol Coated Steel – Products including decks, platforms, steps, and bridges shall be fabricated from 12 gauge perforated steel with a .08" minimum thickness, textured slip-resistant polyvinyl chloride plastisol dipped coating. Square deck size must be at least 36" x 36" (1,296 square inches), and triangular decks must be equally 36" on all sides (561 square inches). Decks must attach directly to threaded inserts factory installed to uprights, using (1) 3/8" bolts at each upright connection point to eliminate the possibility of deck slipping. Plastisol coating must be free of latex and tested to meet California standards for phthalate levels and safe for children.
4. Molded Polyethylene – Products are to be rotationally molded plastic with a 1/4" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive, and be available in any of the manufacturer's standard colors.
5. High Density Polyethylene shall be made from either 1/2" or 3/4" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.
6. Metal Climbers and Enclosures – Products shall be fabricated from 1 5/16" OD x .083" (14 gauge) wall galvanized steel tubing with vertical members fabricated of 1 1/16" OD x .075 (15 gauge) wall galvanized steel tubing. All tubing used shall be an electrical resistance welded, cold rolled, high strength steel tubing. The exterior coating will consist of an in line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion, and acrylic over-coating. The interior coating will consist of a special organic acrylic modified polyester.
7. Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.
8. Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate top coat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing.

B. REQUIRED COMPONENTS

1. In addition to the requirements contained in this section, refer to layout drawings and schedules of components and accessories on drawings.
2. All components, accessories, hardware, and other items required for a complete and usable system shall be provided.

C. FINISHES

1. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.
2. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

5.3 EXECUTION**A. INSTALLATION**

1. General – Comply with manufacturer's written installation instructions.
2. Uprights – Set posts in concrete footings. Protect finish during installation. Comply with locations, height, and plumb requirements.

B. FIELD QUALITY CONTROL

1. Installation shall be performed by factory certified technicians with at least 3 years' experience installing playground equipment

C. COMPLETION

1. Protect installed products until completion of project.
2. Touch up, repair, or replace damaged products before substantial completion.
3. Installer shall turn over all installation instructions, parts lists, maintenance instructions, tool kits, and spare materials to the owner upon completion.

PART 6 - XSCAPE PLAY SYSTEMS**6.1 GENERAL****A. SUMMARY**

1. Section includes composite structure, stand-alone play events and accessories.
2. Basis of design is Xscape® modular play structures, free-standing play equipment and accessories as manufactured by GameTime, a PlayCore Company, P.O. Box 680121, Fort Payne, Alabama 35968-0121, Phone: 1-800-235-2440, www.GameTime.com.

B. SUBMITTALS

1. Product Data: Include physical characteristics such as shape, dimensions, gauge and material for each component. Provide finish information and available colors.
2. Shop Drawings: Include plans, elevations, details, and installation instructions for each component.
3. Warranty: Include sample of manufacturer's standard warranty.

C. QUALITY ASSURANCE

1. Manufacturer Qualifications: Equipment components shall be certified by IPEMA's third party product certification service. Equipment and structural components shall bear the IPEMA certification seal. IPEMA validation is available at www.ipema.org.
2. Installer: Must be certified by the manufacturer.
3. Safety Standards: Comply with requirements of ASTM F 1487.

D. WARRANTY

1. Warranty shall meet or exceed the warranty provisions of GameTime as follows:
 - a. Lifetime limited warranty on PowerScape®, PrimeTime®, Modern City®, Xscape® & IONiX® uprights.
 - b. Lifetime limited warranty on Tru-Loc® connections and upright bolt-through connections.
 - c. Lifetime limited warranty on all hardware.
 - d. 20-Year limited warranty on Timber Décor™ & Timbers recycled plastic lumber.
 - e. 15-Year limited warranty on metal decks, pipes, rungs, rails, loops, braces, and foot bucks.
 - f. 15-Year limited warranty on rotationally molded products.
 - g. 15-Year limited warranty on VistaRope nylon bearings and ring junction pieces.
 - h. 10-Year limited warranty on GTFit, THRIVE and Challenge Course posts & bars.
 - i. 10-Year limited warranty on site furnishings against structural failure.
 - j. 10-Year limited warranty on SunBlox® products.
 - k. 10-Year limited warranty on integrated GTShade® products.
 - l. 10-Year limited warranty on fiberglass and DHPL signage.
 - m. 10-Year limited warranty on VistaRope WeaveTech cables.
 - n. 5-Year limited warranty on TuffForms® structures, including TuffCrete™ and PolyShield.
 - o. 5-Year limited warranty on nylon covered cable net climbers and components.
 - p. 5-Year limited warranty on GT Symphony Freenotes™ Harmony Park components.
 - q. 5-Year limited warranty on Super Seats™.
 - r. 5-Year limited warranty on premature wear of VistaRope cables.
 - s. 3-Year limited warranty on Everybody Plays polyurea coated foam & rubber strips.
 - t. 3-Year limited warranty on SaddleMates® rubber and "C" springs.
 - u. 3-Year limited warranty on SureGrip Material
 - v. 1-Year limited warranty on Challenge Course timing components.
 - w. 1-Year limited warranty on all other GameTime products.

6.2 PRODUCTS

A. MATERIALS

1. Main Structural Uprights shall be 3.5" outside diameter, 13 gauge (nominal .095") galvanized round tubing, manufactured to ASTM A-500 Grade B tolerances from cold-formed steel conforming to ASTM A-1011 Sheet Spec for steel coil. Minimum yield strength shall be 45,000 psi and minimum tensile strength shall be 48,000 psi. The exterior surface is In line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion coated, and a clear high performance organic polymer is applied. Galvanizing coverage shall demonstrate the ability to exceed 1000 hours salt spray corrosion exposure in accordance with ASTM B-117. Internal surface zinc rich 91% minimum zinc dust content in organic resin, as per ASTM F-1043. All upright posts shall be coated with a custom formula TGIC.
2. Component Attachment – Must be factory preset to the uprights to ensure full field compliance with current safety standards. Hinges, or any clamps, that require field locating or field drilling or installation are not acceptable, due to the susceptibility of installation out of compliance with safety standards.
3. Plastisol Coated Steel – Platforms and steps shall be fabricated from 12-gauge perforated steel with a .08" minimum thickness, textured slip-resistant polyvinyl chloride plastisol dipped coating. Platforms must attach directly to support frame, using 3/8" bolts at each connection point. Plastisol coating shall be free of latex and tested to meet California standards for phthalate levels and safe for children. Available in manufacturers standard colors.
4. Molded Polyethylene – Products are to be rotationally molded plastic with a 1/4" nominal wall thickness. All plastic is to be U.V. stabilized with optional graphics molded into the component during the molding process. Molded products shall have an anti-static additive and be available in any of the manufacturer's standard colors.
5. High Density Polyethylene - Products shall be made from either 1/2" or 3/4" thick (depending on application used) high density, UV-stabilized and color impregnated polyethylene.
6. Metal Climbers and Enclosures – Products shall be fabricated from 1 5/16" OD x .083" (14 gauge) wall galvanized steel tubing with frames fabricated of 2 3/8" OD x .134 (10 gauge) wall galvanized steel tubing. All tubing used shall be an electrical resistance welded, cold rolled, high strength steel tubing. The exterior coating will consist of an in-line Zinc Flo Coating with a zinc coating of .03 thickness minimum, chromate conversion, and acrylic over-coating. The interior coating will consist of a special organic acrylic modified polyester. All climbers shall be coated with a custom formula TGIC.
7. Cables - shall be 18mm polyester twisted type with the following properties: calculated tensile strength of >60kN, quantity 6 strands 2.8mm diameter each, steel strands shall have QTY 19 steel wires diameter .62mm each, quantity 3 fiber core 2.7mm diameter each, UV protected polyester impregnated. Terminations shall be made of the following materials: Aluminum forks, stainless steel D-shackles, stainless steel lifting eye nuts. Connections shall be made of the following: Aluminum connector eggs, aluminum 2-piece T-joints, aluminum T-joints, aluminum in-line connector, aluminum ferrules.

8. Hardware – All nuts, bolts, screws, inserts, and lock washers used in the assembly of all play equipment shall be stainless steel, yellow dichromate plated steel, blue-coat plated steel, mechanically galvanized or powder coated/yellow dichromate plated steel. All primary fasteners shall be 304 alloy stainless steel. Fasteners with yellow dichromate treatment have an electro-deposited, 99.9% pure zinc substrate applied from a specially formulated solution sealed with a yellow dichromate topcoat designed to work in conjunction with the zinc plating. Yellow dichromate has a 320% longer life to white corrosion and 275% longer to red corrosion than does hot-dip galvanizing.

B. REQUIRED COMPONENTS

1. In addition to the requirements contained in this section, refer to layout drawings and schedules of components and accessories on drawings.
2. All components, accessories, hardware, and other items required for a complete and usable system shall be provided.

C. FINISHES

1. Polyester (Powder) Coating – The polyester coating shall be uniformly applied by the electrostatic method to a minimum thickness of four mils. Promptly after application of the powder, the coating shall be oven-cured at 350 degrees Fahrenheit. The color(s) of the polyester coating shall be as selected by the Architect from the manufacturer's standard and/or custom color selection charts. The paint process must adhere to the Powder Coat Institute 4000 Certification.
2. Galvanized Finish – All components shall have a galvanized finish prior to powder coating and shall be protectively coated with ZRP, a zinc primer that forms a rust-resistant barrier layer. All galvanized surfaces shall be free of burs, splinters, and sharp edges.

6.3 EXECUTION

A. INSTALLATION

1. General – Comply with manufacturer's written installation instructions.
2. Uprights – Set posts in concrete footings. Protect finish during installation. Comply with locations, height, and plumb requirements.

B. FIELD QUALITY CONTROL

1. Installation shall be performed by factory certified technicians with at least 3 years' experience installing playground equipment

C. COMPLETION

1. Protect installed products until completion of project.
2. Touch up, repair, or replace damaged products before substantial completion.
3. Installer shall turn over all installation instructions, parts lists, maintenance instructions, tool kits, and spare materials to the owner upon completion.

SECTION 32 1816.13 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Unitary, seamless surfacing.

1.2 DEFINITIONS

- A. Definitions in ASTM F2223 apply to Work of this Section.
- B. Critical Height: Standard measure of shock attenuation according to ASTM F2223; same as "critical fall height" in ASTM F1292. According to ASTM F1292, this approximates "the maximum fall height from which a life-threatening head injury would not be expected to occur."
- C. SBR: Styrene-butadiene rubber.
- D. Unitary Surfacing: A protective surfacing of one or more material components bound together to form a continuous surface; same as "unitary system" in ASTM F2223.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
- C. Shop Drawings: For each type of protective surfacing.
 - 1. Include plans, sections, placement details, and attachment to substrates.
 - 2. Include accessories and edge terminations.
 - 3. Include fall heights and use zones for equipment and structures specified in Section 11 6800 "Play Field Equipment and Structures," coordinated with the critical heights for protective surfacing.
- D. Samples for Initial Selection: For each type of exposed finish.
 - 1. Include Samples of accessories involving color selection.
- E. Samples for Verification: For each type of protective surfacing and exposed finish.
 - 1. Include Samples of accessories to verify color and finish selection.
 - 2. Unitary, Seamless Surfacing: Minimum 6 by 6 inches.
- F. Product Schedule: For protective surfacing. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.

- B. Product Certificates: For each type of unitary surfacing product.
- C. Field quality-control reports.
- D. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For playground protective surfacing to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace components of protective surfacing that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Reduction in impact attenuation as measured by reduction of critical fall height.
 - b. Deterioration of protective surfacing and other materials beyond normal weathering.
 - 2. Warranty Period: Eight years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain protective surfacing materials from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: Critical fall height tested according to ASTM F1292.
- B. Accessibility Standard: Minimum surfacing performance according to ASTM F1951.

2.3 UNITARY, DUAL-DENSITY, SEAMLESS SURFACING

- A. Description: Manufacturer's standard, site-mixed and applied, two-layer material with wearing layer over cushioning layer, with combined, overall thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
- B. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Rubberecycle

- C. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for subgrade elevations, slope, and drainage and for other conditions affecting performance of the Work.
 - 1. Verify that substrates are sound and without high spots, ridges, holes, and depressions.
- B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary, protective surfacing installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to protective surfacing manufacturer's written requirements for cross-section profile.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prepare substrates to receive surfacing products according to protective surfacing manufacturer's written instructions.

3.3 INSTALLATION OF SEAMLESS SURFACING

- A. Mix and apply components of seamless surfacing according to manufacturer's written instructions to produce uniform, monolithic, and impact-attenuating protective surfacing of required overall thickness.
 - 1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
 - 2. Poured Cushioning Layer: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
 - 3. Intercoat Primer: Over cured cushioning layer, apply primer at manufacturer's standard spreading rate.
 - 4. Wearing Layer: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with a minimum of cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
 - 5. Edge Treatment: As indicated on Drawings. Fully adhere edges to substrate with full coverage of substrate. Maintain fully cushioned thickness required to comply with performance requirements.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests.

- B. Perform the following tests with the assistance of a factory-authorized service representative:
 - 1. Perform "Installed Surface Performance Test" according to ASTM F1292 for each protective surfacing type and thickness in each playground area.
 - 2. Perform installed-surface-performance tests at no less than one series of tests for each 1000 sq. ft. of each type and thickness of in-place protective surfacing or part thereof.
- C. Playground protective surfacing will be considered defective if it does not pass tests.
- D. Prepare test reports.

3.5 PROTECTION

- A. Prevent traffic over seamless surfacing for not less than 48 hours after installation.

END OF SECTION 32 1816.13

SECTION 32 3113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Chain-link fence framework.
 - 2. Chain-link fence fabric.
 - 3. Chain-link fittings.
 - 4. Chain-link wires and ties.
 - 5. Chain-link swing gates.
- B. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for cast-in-place concrete for post footings.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - b. Fence and gate posts, rails, and fittings.
 - c. Chain-link fabric, reinforcements, gate types, hardware, and attachments.
 - d. Gates and hardware.
- B. Shop Drawings: For each type of fence and gate assembly.
 - 1. Include plans, elevations, sections, ground details, post spacing, and attachments to other work.
 - 2. Include accessories and hardware.
- C. Samples for Initial Selection: For each type of factory-applied finish.
- D. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:
 - 1. Polymer-Coated Components: In 6-inch lengths for components and on full-sized units for accessories.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of chain-link fence, and gate.
- B. Product Test Reports: For framework strength in accordance with ASTM F1043, for tests performed by a qualified testing agency.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 FIELD CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fences that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure to comply with performance requirements.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Structural Performance: Chain-link fence and gate frameworks are to withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated in accordance with ASCE/SEI 7.
 - 1. Design Wind Load: based on 60 mph wind speed.
 - a. Minimum Post Size: Determine in accordance with ASTM F1043 for post spacing not to exceed 10 feet for Material Group IA, ASTM F1043, Schedule 40 steel pipe.
- B. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.
- C. Accessibility: Pedestrian gates to comply with the United States Access Board's ADA-ABA Accessibility Guidelines.

2.2 CHAIN-LINK FENCES, GENERAL

- A. CLFMI Publications: Comply with the CLFMI Product Manual unless modified by requirements in the Contract Documents.

- B. Chain-Link Fence and Gate Assemblies: Include materials applicable for a complete assembly of application types, consisting of commercial, industrial, and security chain-link fences and gates.
 - 1. Source Limitations: Obtain chain-link fence and gate components from single source or manufacturer.

2.3 CHAIN-LINK FENCE FRAMEWORK

- A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thicknesses in accordance with ASTM F1043 based on the following:
 - 1. Fence Height: 48 inches.
 - 2. Light-Industrial-Strength Material: Group IC-L, round steel pipe, electric-resistance-welded pipe.
 - a. Line Post: 2.375 inches in diameter.
 - b. End, Corner, and Pull Posts: 2.875 inches.
 - 3. Horizontal Framework Members: top and bottom rails in accordance with ASTM F1043.
 - a. Top Rail: 1.66 inches in diameter.
 - 4. Brace Rails: ASTM F1043.
 - 5. Metallic Coating for Steel Framework:
 - a. Type A: Not less than minimum 2.0 oz./sq. ft. average zinc coating in accordance with ASTM A123/A123M or 4.0 oz./sq. ft. zinc coating in accordance with ASTM A653/A653M.
 - 6. Polymer coating over metallic coating.
 - a. Color: As designated on the Drawings, in accordance with ASTM F934.

2.4 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist in accordance with "CLFMI Product Manual" and requirements indicated below:
 - 1. Fabric Height: 4 feet.
 - 2. Steel Wire for Fabric: Wire diameter of 0.192 inch.
 - a. Mesh Size: 2 inches.
 - b. Zinc-Coated Fabric: ASTM A392, Type II, Class 1, 1.2 oz./sq. ft. with zinc coating applied after weaving.
 - c. Polymer-Coated Fabric: ASTM F668, Class 1 over zinc-coated steel wire.
 - 1) Color: as indicated on the Drawings, in accordance with ASTM F934.
 - 3. Selvage: Knuckled at both selvages.

2.5 CHAIN-LINK FITTINGS

- A. Provide fittings in accordance with ASTM F626.
- B. Post Caps: Provide for each post.
 - 1. Provide line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.

- D. Rail Fittings: Provide the following:
 - 1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches long.
 - 2. Rail Clamps: Line and corner boulevard clamps for connecting bottom rails to posts.
- E. Tension and Brace Bands: Pressed steel.
- F. Tension Bars: Steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: In accordance with ASTM F626.
 - 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, in accordance with the following:
 - a. Hot-Dip Galvanized Steel: 0.192 inch diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.
- I. Finish:
 - 1. As indicated on the Drawings.

2.6 CHAIN-LINK WIRE AND TIES

- A. Metallic-Coated Steel Wire: 0.177-inch- diameter, marcelled tension wire in accordance with ASTM A817 or ASTM A824, with the following metallic coating:
 - 1. Type II: Zinc coated (galvanized) by hot-dip process, with the following minimum coating weight:
 - a. Matching chain-link fabric coating weight.
- B. Polymer-Coated Steel Wire: 0.192 inch diameter, tension wire in accordance with ASTM F1664, Class 1 over zinc-coated steel wire.
 - 1. Color: As indicated on the Drawings, in accordance with ASTM F934.

2.7 CHAIN-LINK SWING GATES

- A. General: ASTM F900 for gate posts and double swing gate types.
 - 1. Gate Leaf Width: 48 inches.
 - 2. Framework Member Sizes and Strength: Based on gate fabric height of 72 inches or less.
- B. Swing Gate Pipe and Tubing:
 - 1. Swing Gate Posts: Round tubular steel.
 - 2. Gate Frames and Bracing: Round tubular steel.
 - 3. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework.

- C. Swing Gate Hardware:
 - 1. Hinges: 180-degree inward swing.
 - 2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
 - 3. Padlock and Chain: Provide to the Owner.

2.8 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.9 CONCRETE

- A. Concrete Post Footings: Minimum 28-day compressive strength of 3500 psi.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a certified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 - 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION OF CHAIN-LINK FENCES

- A. Install chain-link fencing in accordance with ASTM F567 and more stringent requirements specified.
 - 1. Install fencing on established boundary lines inside property line.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

- C. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend 2 inches above grade; shape and smooth to shed water.
- D. Terminal Posts: Install terminal end, corner, and gate posts in accordance with ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.
- E. Line Posts: Space line posts uniformly at 10 feet o.c.
- F. Post Bracing and Intermediate Rails: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
 - 1. Locate horizontal braces at midheight of fabric 72 inches or higher, on fences with top rail, and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- G. Top Rail: Install in accordance with ASTM F567, maintaining plumb position and alignment of fence posts. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- H. Intermediate and Bottom Rails: Secure to posts with fittings.
- I. Chain-Link Fabric: Apply fabric to inside of enclosing framework. Leave 4 inch bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts, with tension bands spaced not more than 15 inches o.c.
- K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric in accordance with ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.
- L. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side.

3.4 INSTALLATION OF GATES

- A. Install gates in accordance with manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests.
- B. Prepare test reports.

3.6 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Lubricate hardware and other moving parts.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 32 3113

SECTION 32 9113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes planting soils specified by composition of the mixes.
- B. Related Requirements:
 - 1. Section 31 1000 "Site Clearing" for topsoil stripping and stockpiling.
 - 2. Section 32 9200 "Turf and Grasses" for placing planting soil for turf and grasses.

1.2 DEFINITIONS

- A. AAPFCO: Association of American Plant Food Control Officials.
- B. Backfill: The earth used to replace or the act of replacing earth in an excavation. This can be amended or unamended soil as indicated.
- C. Compost: The product resulting from the controlled biological decomposition of organic material that has been sanitized through the generation of heat and stabilized to the point that it is beneficial to plant growth.
- D. Imported Soil: Soil that is transported to Project site for use.
- E. Layered Soil Assembly: A designed series of planting soils, layered on each other, that together produce an environment for plant growth.
- F. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.
- G. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."
- H. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- I. SSSA: Soil Science Society of America.
- J. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- K. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

- L. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- M. USCC: U.S. Composting Council.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include recommendations for application and use.
 - 2. Include test data substantiating that products comply with requirements.
 - 3. Material Certificates: For each type of soil amendment and fertilizer before delivery to the site, according to the following:
 - a. Manufacturer's qualified testing agency's certified analysis of standard products.
 - b. Analysis of fertilizers, by a qualified testing agency, made according to AAPFCO methods for testing and labeling and according to AAPFCO's SUIP #25.
 - c. Analysis of nonstandard materials, by a qualified testing agency, made according to SSSA methods, where applicable.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and compliance with state and Federal laws if applicable.
- B. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Do not move or handle materials when they are wet or frozen.
 - 4. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.

PART 2 - PRODUCTS

2.1 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:
 - 1. Feedstock: Limited to leaves.
 - 2. Reaction: pH of 5.5 to 8.
 - 3. Soluble-Salt Concentration: Less than 4 dS/m.
 - 4. Moisture Content: 35 to 55 percent by weight.
 - 5. Organic-Matter Content: 30 to 40 percent of dry weight.

2.2 FERTILIZERS

- A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
- D. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Place planting soil and fertilizers according to requirements in other Specification Sections.
- B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.
- C. Proceed with placement only after unsatisfactory conditions have been corrected.

3.2 COMPOST TO SURFACE OF PLANTING SOIL

- A. Application: Apply compost component of planting-soil mix to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.3 PROTECTION

- A. Protection Zone: Identify protection zones according to Section 01 5639 "Temporary Tree and Plant Protection."

- B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Vehicle traffic.
 - 4. Foot traffic.
 - 5. Erection of sheds or structures.
 - 6. Impoundment of water.
 - 7. Excavation or other digging unless otherwise indicated.
- C. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by Architect and replace contaminated planting soil with new planting soil.

3.4 CLEANING

- A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.
- B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

END OF SECTION 32 9113

SECTION 32 9200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Seeding.
 - 2. Hydroseeding.

1.2 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 32 9113 "Soil Preparation" and drawing designations for planting soils.
- E. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture, stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
- C. Product Certificates: For fertilizers, from manufacturer.
- D. Pesticides and Herbicides: Product label and manufacturer's application instructions specific to Project.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf establishment.
 - 1. Professional Membership: Installer shall be a member in good standing of either the National Association of Landscape Professionals or AmericanHort.
 - 2. Experience: Three years' experience in turf installation in addition to requirements in Section 01 4533 "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the National Association of Landscape Professionals:
 - a. Landscape Industry Certified Technician - Exterior.
 - b. Landscape Industry Certified Lawn Care Manager.
 - c. Landscape Industry Certified Lawn Care Technician.
 - 5. Pesticide Applicator: State licensed, commercial.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk materials with appropriate certificates.

1.7 FIELD CONDITIONS

- A. Planting Restrictions: Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion. Refer to plans for seeding window.

- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species:
 - 1. Quality, State Certified: State-certified seed of grass species as listed below for solar exposure.
 - 2. Quality, Non-State Certified: Seed of grass species as listed below for solar exposure, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.35 percent weed seed.
 - 3. Refer to plans for seed mixture.

2.2 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition:
 - a. 1 lb/1000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

2.3 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- C. Asphalt Emulsion: ASTM D977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.4 PESTICIDES

- A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

- B. Pre-Emergent Herbicide (Selective and Nonselective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Nonselective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting installation and performance of the Work.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Suspend planting operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 3. Uniformly moisten excessively dry soil that is not workable or which is dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures; utilities; sidewalks; pavements; and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

- A. General: Prepare planting area for soil placement.
- B. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
 - 1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 2. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 8 lb/1000 sq. ft..
- C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
 - 1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

3.5 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, commercial fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with nonasphaltic tackifier.
 - 2. Spray-apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.6 TURF MAINTENANCE

- A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.

- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 - 1. Mow Kentucky bluegrass to a height of 1-1/2 to 2 inches.
- D. Turf Postfertilization: Apply commercial fertilizer after initial mowing and when grass is dry.
 - 1. Use fertilizer that provides actual nitrogen of at least 1 lb/1000 sq. ft. to turf area.

3.7 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 - 1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
- B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

3.8 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents according to requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Nonselective): Apply only as necessary to treat already-germinated weeds and according to manufacturer's written recommendations.

3.9 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.

- C. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- D. Remove nondegradable erosion-control measures after grass establishment period.

3.10 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in "Turf Maintenance" Article. Begin maintenance immediately after each area is planted and continue until acceptable turf is established, but for not less than the following periods:
 - 1. Seeded Turf: 60 days from date of planting completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

END OF SECTION 32 9200

SECTION 33 4600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Perforated-wall pipes and fittings.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

- A. Perforated PE Pipe and Fittings:
 - 1. NPS 6 (DN 150) and Smaller: ASTM F405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - 2. NPS 8 (DN 200) and Larger: ASTM F667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
 - 3. Couplings: Manufacturer's standard, band type.
- B. Perforated PVC Sewer Pipe and Fittings: ASTM D2729, bell-and-spigot ends, for loose joints.

2.2 SOIL MATERIALS

- A. Soil materials are specified in Section 31 2000 "Earth Moving."

2.3 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested in accordance with ASTM D4491.
- B. Structure Type: Nonwoven, needle-punched continuous filament.
 - 1. Survivability: AASHTO M 288 Class 2.
 - 2. Styles: Flat and sock.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 31 2000 "Earth Moving."

3.3 INSTALLATION OF PIPING

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's written instructions and other requirements indicated.
 - 1. Lay perforated pipe with perforations down.
 - 2. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install thermoplastic piping in accordance with ASTM D2321.

3.4 CONSTRUCTION OF PIPE JOINTS

- A. Join perforated PE pipe and fittings with couplings in accordance with ASTM D3212 with loose banded, coupled, or push-on joints.
- B. Join perforated PVC sewer pipe and fittings in accordance with ASTM D3212 with loose bell-and-spigot, push-on joints.
- C. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
 - 2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
- B. Drain piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 4600

Document Request Procedure

Owners, Contractors or other Consultants may from time-to-time request electronic files from C2AE as records, backgrounds, use in shop drawing preparation or preparation of a new project.

In support of these requests, follow these steps:

1. Requesting party fills out this form, including name, contact and requested files, as well as the purpose for the request.
2. Submit form to C2AE (info@c2ae.com) or the C2AE project manager.
3. C2AE project manager will determine that the requested files are suitable for release and develop a cost of delivering the requested files and return form to Requesting Party for signature.
4. Requesting party will return signed form and payment for cost of delivery.
5. C2AE will return signed form with files.
6. An AIA E203 Building Information Modelling and Digital Data Exhibit may be used as an alternative to the form below.

Electronic Media Release, Disclaimer and Release of Claims

1. The parties to this agreement, Capital Consultants, Inc., dba "C2AE" in Michigan and dba "Capital Consultants Architecture and Engineering" in New York, hereinafter called the A/E CONSULTANT and OWNER / CONTRACTOR, hereinafter called the REQUESTOR, hereby agree that the A/E CONSULTANT will release Documents, as herein defined via electronic media, to the REQUESTOR. The parties hereto agree to the following:
2. In addition to other rights of ownership or use which may be granted to the REQUESTOR under this Agreement, the REQUESTOR shall be permitted to retain electronic or machine readable copies of the A/E CONSULTANT's Drawings, Specifications and other documents (collectively referred to as the Documents), and shall be permitted to use electronic or machine readable copies of the Documents for information and reference.
3. Under no circumstances shall the transfer of possession or ownership of physical copies of the Documents or of the physical media upon which electronic or machine readable copies of the Documents exist be deemed to be a sale by the A/E CONSULTANT of the Documents or of the information and data contained therein. The A/E CONSULTANT makes no representations or warranties, either express or implied, of merchantability, of fitness for a particular purpose, or with respect to the Documents quality, adequacy, completeness, or sufficiency, or with respect to any results to be or intended to be achieved with respect to their use. In no event shall we be liable for any loss of profit or any consequential damages as a result of your use or reuse of these electronic files.
4. The REQUESTOR acknowledges that the information and data delivered to the REQUESTOR in electronic or machine readable copies of the Documents may vary from that contained on physical copies of the Documents released for the purposes of bidding, construction or record drawings. Variances may be due to the use of different software, hardware, or output devices by the REQUESTOR or others from those used by the ENGINEER/ARCHITECT in originally preparing and printing the Documents. Variances may also be the result of the manner in which software used to convert the Documents from the system or format employed by the A/E CONSULTANT to that of the REQUESTOR or others translates the information and data contained on the Documents. Variances may also be the result of undocumented changes or

modifications made to the electronic or machine readable Documents, whether inadvertently or otherwise, and whether made by the REQUESTOR or others. The A|E CONSULTANT, therefore, reserves the right to retain the electronic or machine readable media upon which the Documents were originally prepared, and to retain physical copies of the Documents delivered to the REQUESTOR in electronic or machine readable form, which physical copies shall govern in the event of any inconsistency or discrepancy between the two. Media and physical copies will be retained by the A|E CONSULTANT for a period not to exceed five (5) years from the date noted herein. We make no representation as to the compatibility of these files with your hardware or software beyond the specified release of the referenced software.

5. For use in construction, these electronic files are not construction documents or record documents. Differences may exist between these electronic files and corresponding hard-copy construction documents or record drawings. We make no representation regarding the accuracy or completeness of the electronic files you receive. In the event that a conflict arises between the signed or sealed hard-copy construction documents prepared by us and the electronic files, the signed or sealed hard-copy construction documents shall govern. You are responsible for determining if any conflict exists. By your use of these electronic files, you are not relieved of your duty to fully comply with the contract documents, including, and without limitation, the need to check, confirm, and coordinate all dimensions and details, take field measurements, verify field conditions and coordinate your work with that of other contractors for the project.
6. Data contained in these electronic files are part of our instruments of service and shall not be used by you or anyone else receiving these data through or from you for any purpose other than as stated in the request. Any other use or reuse by you or by others will be at your sole risk and without liability or legal exposure to us. You agree to make no claim and hereby waive, to the fullest extent permitted by law, any claim or cause of action of any nature against us, our officers, directors, employees, agents, or subconsultants that may arise out of or in connections with your use of the electronic files.
7. Because information presented on the electronic files can be modified, unintentionally or otherwise, we reserve the right to remove all indicia of ownership and/or involvement from each electronic display.
8. When the list of sheets, drawing files, models or other media is requested, C2AE will develop a cost of delivery to cover preparation time, any modifications required to protect sensitive information and final delivery. The delivery cost must be paid before the files are delivered.
9. In consideration of the A|E CONSULTANT's willingness to deliver electronic or machine readable copies of the Documents for the REQUESTOR's use as described above, and of the risks to the A|E CONSULTANT of inconsistencies, discrepancies or undocumented changes or modifications to the Documents, the REQUESTOR agrees to assume all risks associated with the use and modification, by the REQUESTOR or others, of electronic or machine readable copies of the Documents and, to the fullest extent permitted by law, to release, hold harmless, and to indemnify the A|E CONSULTANT, and to defend the A|E CONSULTANT using counsel satisfactory to the A|E CONSULTANT, from and against all claims, liabilities, losses, damages, judgments, awards, and costs including, but not limited to, court costs and attorneys fees, arising from, related to, or in any manner in connection with the use or modification by the REQUESTOR or others of electronic or machine readable copies of the Documents.

REQUESTOR Name and Firm

Reason for Request / Purpose/Usage of the requested files: _____

Address _____

City, State, Zip _____

Phone _____

Email _____

C2AE

REQUESTOR:

BY: _____

BY: _____

TITLE: _____

TITLE: _____

WITNESS: _____

WITNESS: _____

DATE: _____

C2AE Job No. _____

List of Files Requested:

Current File Format (C2AE will report)

1. _____

2. _____

C2AE Cost of Delivery: \$ _____

REQUEST FOR SUBSTITUTION

TO: _____ DATE: _____

PROJECT: 24-0256 Grand Rapids Public Schools- Alger School Renovations

SECTION	PARAGRAPH	SPECIFIED ITEM
_____	_____	_____

PROPOSED SUBSTITUTION: _____ MODEL: _____

MANUFACTURER: _____ PHONE: (____) _____

Include product description, specifications, drawings, photographs, performance and test data adequate for evaluation. Clearly identify applicable portions of the data. Also include description of changes to contract documents that would be required as a result of the substitution.

The undersigned states that the following line items, unless modified on attachments, are correct:

- A. I have read and fully understand the conditions for substitutions outlined in this specification section.
- B. The proposed substitution does not affect dimensions shown on drawings.
- C. The undersigned will reimburse architect for any building design changes required due to the substitution, including engineering, detailing, and services associated with re-approval by authorities.
- D. I will coordinate installation and make both known and unforeseen changes to other work required for substitution at no additional cost to the owner.
- E. The proposed substitution will have no adverse effect on other trades, the construction schedule, or specified warranty requirements.
- F. Maintenance and service parts will be locally available for the proposed substitution.
- G. The undersigned further states that the function, appearance, and quality of the proposed substitutions are equivalent or superior to the specified item.

SUBMITTED BY: _____

SIGNATURE _____

FIRM _____

ADDRESS _____

TELEPHONE (____) _____

FAX (____) _____

FOR USE BY C2AE

ACCEPTED

ACCEPTED AS NOTED

NOT ACCEPTED

RECEIVED TOO LATE

BY _____

DATE _____

REMARKS _____