UNIVERSITY OF UTAH
BIOLOGY BLDG 84
FUME HOOD REPLACEMENT
PHASE 2

UNIVERSITY PROJECT NUMBER: PROJ-22437

THE UNIVERSITY OF UTAH

PROJECT MANUAL

Permit Set

October 13, 2021

David L. Jensen & Associates
547 West 500 South, # 140
Bountiful, Utah 84010
Phone (801) 294-9299

KW Engineering
329 E 2100 S
Salt Lake City, UT 84115
Phone: (801) 657-4497

REGISTERED PROFESSIONAL ENGINEER
No. 181307
HAL L. ABERCROMBIE
STATE OF UTAH
EXP. 03/31/23

Architect
TSA Architects
1486 S 1100 E
Salt Lake City, UT 84105
Phone: (801) 463-7108

STATE OF UTAH
NO. 135781
TRACY D. STOCKING
5/31/2022
LICENSED ARCHITECT

Electrical Engineering Firm
Envision Engineering PC
240 E Morris Ave., Ste 200
Salt Lake City, UT 84115
Phone: (801) 534-1130

PROFESSIONAL ENGINEER
10/13/2021
8357784-2202
EXP. 03/31/2023
TREVOR REED SPENCER
STATE OF UTAH

Structural Engineer
BHB Consulting Engineers
2766 S Main Street
Salt Lake City, UT 84115
Phone: (801) 355-5656

LICENSED PROFESSIONAL STRUCTURAL ENGINEER
10/13/2021
BRETT KARL GOODMAN
No. 7991094-2203
STATE OF UTAH
exp. 03/21/2022

Construction Documents

PROJECT MANUAL TABLE OF CONTENTS

U of U Bldg 84
Fume Hood Replacement Phase 2
U of U Project # 22437

Section	Title
PROJECT MANUAL TABLE OF CONTENTS	
DIVISION 01 –	
01 9113	GENERAL COMMISSIONING REQUIREMENTS
DIVISION 02 – SITE CONSTRUCTION	
02 4119	SELECTIVE STRUCTURE DEMOLITION
DIVISION 05 – METALS	
05 5430	SLOTTED CHANEL FRAMING
DIVISION 07 – THERMAL & MOISTURE PROTECTION	
07 5401	PVC ROOFING
07 8400	FIRE STOPPING
07 9213	ELASTOMERIC JOINT SEALANTS
DIVISION 09 – FINISHES	
09 2226	METAL SUSPENSIONS SYSTEM: GYPSUM BOARD
09 2900	GYPSUM WALLBOARD
09 5113	ACOUSTIC PANEL CEILINGS
09 5300	ACOUSTIC CEILING SUSPENSION ASSEMBLIES
09 9123	INTERIOR PAINTING
DIVISION 21 – FIRE SUPPRESSION	
21 0500	COMMON WORK RESULTS FOR FIRE SUPPRESSION
21 0529	HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING & EQUIPMENT
21 0548	VIBRATION & SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING & EQUIP
21 0553	IDENTIFICATION FOR FIRE-SUPPRESSION PIPING & EQUIPMENT
21 1313	WET-PIPE SPRINKLER SYSTEMS
DIVISION 22 - PLUMBING	
22 0500	COMMON WORK RESULTS FOR PLUMBING
22 0523.12	BALL VALVES FOR PLUMBING PIPING
22 0529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 0548	VIBRATION & SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

22 0553 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
22 0719 PLUMBING PIPING INSULATION
22 0800 COMMISSIONING OF PLUMBING SYSTEMS
22 1116 DOMESTIC WATER PIPING **(Copper)**
22 1119 DOMESTIC WATER PIPING SPECIALTIES
22 6113 COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES
22 6119 COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES
22 6213 VACUUM PIPING FOR LABORATORY & HEALTHCARE FACILITIES
22 6600 CHEMICAL-WASTE SYSTEMS FOR LABORATORY & HEALTHCARE FACILITIES
22 6700 PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

DIVISION 23 – HVAC

23 0500 COMMON WORK RESULTS FOR HVAC
23 0513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 0548 VIBRATION AND SEISMIC CONTROLS FOR HVAC
23 0553 IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 0593 TESTING, ADJUSTING AND BALANCING FOR HVAC
23 0713 DUCT INSULATION
23 0800 COMMISSIONING OF HVAC SYSTEMS
23 0900 INSTRUMENTATION AND CONTROL FOR HVAC
23 0991 FUME HOOD CONTROLS
23 1123 FACILITY NATURAL GAS PIPING
23 3113 METAL DUCTS
23 3300 AIR DUCT ACCESSORIES
23 3423 HVAC POWER VENTILATORS
23 3600 AIR TERMINAL UNITS
23 3713.13 AIR DIFFUSERS
23 3713.23 REGISTERS AND GRILLES

DIVISION 26 – ELECTRICAL

26 0001 ELECTRICAL GENERAL PROVISIONS
26 0080 ELECTRICAL DEMOLITION
26 0519 LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS
26 0526 GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 0529 HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 0533 RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
26 0544 SLEEVES AND SLEEVE SEALS FOR ELETRICAL RACEWAYS AND CABLING
26 0548 SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS
26 0553 IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 2726 WIRING DEVICES
26 0800 COMMISSIONING OF ELECTRICAL SYSTEMS
26 2813 FUSES
28 3111 DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

END OF TABLE OF CONTENTS

SECTION 019113 – GENERAL COMMISSIONING REQUIREMENTS

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.
B. Section 220800 – Commissioning of Plumbing Equipment
C. Section 230800 – Commissioning of HVAC Systems
D. Section 260800 – Commissioning of Electrical Systems
E. Owners Project Requirements (OPR)
F. Basis of Design (BOD)

1.2 DEFINITION

A. Commissioning is a quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained as specified in the Owner's Project Requirements (OPR).

1.3 SCOPE

A. This Section shall form the basis of the construction phase commissioning process. The Commissioning Agent (CxA) shall add, modify, and refine the commissioning procedure to suit field conditions and manufacturers' equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks.
B. The following building systems are within the Commissioning Scope of Work:
   1. Please review Sections 220800, 230800, and 260800.

1.4 QUALITY ASSURANCE

A. The commissioning process shall be conducted in accordance with the following reference documents.
   1. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 202, Commissioning Process for Building and Systems
   2. State of Utah – Department of Administrative Services Division of Facilities Construction and Management (DFCM) Design Requirements, High Performance Building Standards
   3. National Environmental Balancing Bureau (NEBB) – Procedural Standards for Whole Building Systems Technical Commissioning
   4. Building Commissioning Association (BCxA) – New Construction Building Commissioning Best Practice
   5. AABC Commissioning Group Guidelines (ACG) – ACG Commissioning Guideline

PART 2: PRODUCTS (NOT APPLICABLE)

PART 3: EXECUTION

3.1 KICK-OFF AND COMMISSIONG COORDINATION MEETINGS

A. The CxA shall conduct a commissioning kick-off meeting prior to the installation of the building systems outlined in 1.3.B of this Section.
   1. The purpose of the kick-off meeting is present the commissioning plan and provide space to discuss the commissioning process and specific responsibilities of the Contractor.

a. The Cx plan shall clearly delegate responsibility of commissioning tasks to the CxA, Contractor, or members of the Design Team.

2. Attendance is required for the following:

a. Owner's Representative
b. Architect
c. Mechanical Engineer
d. Electrical Engineer
e. General Contractor
f. Mechanical Contractor
g. Electrical Contractor
h. Controls Contractor
i. Water Treatment Contractor
j. Test and Balance Contractor
k. Factory Authorized Service Technicians for the following equipment:

i. Please review Sections 220800, 230800, and 260800

3. Contact information provided on the sign-in sheet at the commissioning kick-off meeting shall be used to create a distribution email list. While every effort shall be made to distribute all pertinent information to the construction team, it is the Contractor's responsibility to ensure that the requirements listed in this Section are fulfilled.

a. The CxA shall distributed meeting minutes for all commissioning meetings.

B. Coordination meetings shall be scheduled among the above entities as required during the construction process.

1. The CxA will provide a minimum of five days' notice before scheduling a coordination meeting.

3.2 COMMISSIONING SCHEDULE

A. Contractor shall supply the CxA with a detailed construction schedule that includes activities of the Contractor and all Subcontractors.
B. The CxA shall supply the Contractor with a detailed commissioning schedule that is based upon the information provided in the construction schedule.
C. Commissioning is a requirement of substantial completion. The building shall be considered "not ready for its intended use" until the CxA verifies the completion of the commissioning process.

1. If substantial completion is awarded to the Owner before the completion of commissioning activities, then the Warranty period for MEP systems shall not begin until the CxA delivers the final commissioning report.

3.3 SUBMITTAL REVIEW

A. The CxA shall notify the Contractor in writing of all construction submittals to be reviewed. It is the responsibility of the Contractor to ensure prompt delivery of the identified construction submittals.
B. The submittal shall include product data, shop drawings, and the manufacturer's installation and startup manual.
C. The CxA shall review the construction submittals concurrently with the Design Team.

1. The commissioning submittal review does not replace the Design Team's submittal review.
2. The CxA shall provide written comments to the design team within ten business days of initial delivery. The submittals will be marked as reviewed, reviewed as noted, defer to engineer, or revise and resubmit. Only revise and resubmit items have the expectation of a resubmittal.

D. The CxA reserves the right to schedule a submittal review meeting for all submittals marked revise and resubmit. This meeting will be scheduled no less than three days in advance. Attendance is mandatory for all parties contacted by the CxA.

3.4 CONSTRUCTION OBSERVATION AND TESTING

A. The proper installation, coordination, testing, and interaction among commissioned systems and assemblies shall be evaluated according to the OPR and Contract Documents.

1. Project-specific construction checklists and testing procedures shall be delivered to the Contractor. These checklists and procedures are open for review and questioning.

   a. Questions and comments shall be provided to the CxA in writing within 30 days of delivery.

B. Once construction checklists and test procedures are established, the responsible Contractor shall execute relevant test protocol and repeat testing as necessary until equipment, systems, or assemblies being tested pass all tests.

1. Contractor shall notify the CxA five business days in advance of any anticipated testing.
2. The CxA directs, witnesses, and documents the tests conducted by the Contractor as required by the Cx Plan.
3. Contractor shall submit test reports to the CxA for review and evaluation.

C. Any commissioned system or assembly that fails to meet requirements and that cannot be resolved in a timely manner shall be given an issue number and recorded in the issues and resolution log to facilitate follow-up.

1. It is the Contractor's responsibility to address the issue. No additional costs will be approved for re-testing.

D. The CxA shall have access to the site to observe construction activities.

1. The CxA shall notify the Contractor five business days before a site visit. The Contractor shall be available during these visits to answer questions.

E. The Contractor shall provide the CxA with access to BIM360 (or equivalent platform) to monitor construction progress and access construction documents.

F. The Contractor shall notify the CxA of any change orders regarding equipment or installation of commissioned systems.

3.5 ISSUES LOG

A. Issues identified during the Cx process shall be documented in an issue and resolution log.

1. The CxA shall maintain and update the log. Detail shall include a description of the problem, a potential resolution, the responsible party, the date the issue was discovered, and the member of the CxA's team who discovered the issue.
2. It is the Contractor's responsibility to address issues weekly. If an issue persists beyond four weeks, the CxA shall request a reduction in payment to the Contractor by the Owner.
3. Upon resolution of an issue, the Contractor shall notify the CxA in writing. The notification shall include how the Contractor addressed the issue and the date of resolution.

B. Each issue in the list will be classified with a "status" of either "resolved", "unresolved" or "resolved-unverified". Resolved issues are closed – having either been addressed by the Contractor and verified as corrected by the CxA or accepted by the owner. Resolved–unverified issues have been reported as resolved by the Contractor but are not yet verified by the CxA as resolved. Unresolved issues have not been reported as addressed by the Contractor. Updated unresolved issues lists will be distributed to team in MS Excel format.

C. Materials and methods issues discovered during commissioning but that pertain to AE construction review will be transferred to the Design Team for tracking through resolution.

When the design team reports the issue resolved, the CxA will classify the issue as Resolved, without back-checking.

D. When a commissioning issue is resolved, the Contractor shall submit the list with a written response describing when and how the issue is resolved. The CxA or the AE shall then back-check the issue. The CxA scope of work includes one back-check of issues that the Contractor reports as resolved. BACK-CHARGING applies to back-checking required due to lack of preparation by Contractor.

3.6 TEST INSTRUMENTATION

A. The Contractor is responsible for providing all test equipment required to conduct readiness testing, pre-functional testing, and functional testing.
B. The test equipment shall be suitable for testing and calibration with accuracy and tolerances necessary to demonstrate that system performance is in accordance with the basis of design.
C. Equipment used for functional testing sensors and gauges shall be certified to an accuracy of 10% of the smallest tolerance to be measured. For example, if a temperature gage is required to be ± 2°F, the calibration device must have a minimum accuracy of ± 0.2°F.
D. Instrumentation used for functional testing system performance must have a minimum repeatability and accuracy of ± 1.0% of the acceptance criteria being measured. For example: if a supply temperature of 50°F is being verified, the repeatability and accuracy of the test instrument must be at least ± 0.5°F.
E. The test equipment shall have calibration certification per equipment manufacturer's interval level or within one year if not specified.

3.7 PRE-FUNCTIONAL CHECKLISTS

A. The purpose of the pre-functional checklist is to certify that a building system is ready for functional testing.
B. The Contractor is responsible for system start-up and completion of the pre-functional test. The completed pre-functional test shall be returned to the CxA.
C. Functional testing shall not be scheduled until completion of the pre-functional checklist.

3.8 FUNCTIONAL TESTING

A. Upon competition of the pre-functional checklist, the form shall be returned to the CxA and a date and time for functional testing shall be selected.
B. Functional testing shall only occur once issues related to installation have been resolved in the issues log.
C. The CxA shall execute functional testing under the supervision and attendance of the Contractor, Controls Contractor, Test and Balance Contractor, Water Treatment Contractor, and Manufacturer's Technician as required.

    1. All required attendees will be given prior notice of the testing date, time, and meeting location at least five business days prior to functional testing.
    2. The Contractor is responsible for all test equipment required to complete the functional performance test.

D. The Contractor shall ensure that:

    1. Functional performance testing can be performed without compromising the safety of the participants.
    2. Functional performance testing can be performed without compromising the warranties of equipment, components, and systems.

E. Completing the functional performance test does not relieve the Contractor from completing other start-up and testing procedures outlined elsewhere in the Project Contract Documents.
F. Acceptance procedures shall confirm the performance of systems to the extent of the design intent. When a system is accepted, the Owner shall be assured that the system is complete, works as intended, is correctly documented, and operator training has been performed.
G. The CxA shall review and test all mechanical, electrical, and plumbing systems.

3.9 TRENDING

A. Trending points shall be outlined in the Procedural Standards as delivered by the CxA in the commissioning plan.
B. A minimum Four (4) weeks of "Clean" trending (no mechanical, software, control loop or Building Management System "BMS" failures) shall be provided on "Any" or "All" BMS systems & points as directed by the C/A. Clean Trending shall be a requirement that is completed prior to Substantial Completion. Trends shall be coincident at 15 minute intervals with a cache able to handle four weeks of trending on a rollover basis.
C. Trending shall be submitted in a graphical Microsoft 2007 Format including all data submitted in the excel workbook. Graphs shall be line graphs shown on printable 11 x 17 pages. Graphs shall included annotations showing compliance with contract documents.
D. ALL points shall be trended and submitted in the above format and as outlined by the Cx Authority. Contractor shall submit during submittal process what shall be trended per each graph to show functionality.
E. If the BMS contractor has the ability to setup the trends in their system and the CxA is allowed full access and the graphs and trends are able to come through on the CxA computer from a remote site then paragraph C shall be fulfilled through this paragraph. The CxA shall review the trends after the four weeks of clean trending.

3.10 PERFORMANCE PERIOD

A. Functional performance testing shall include a performance period test plan, which includes measured variables and success criteria based on performance characteristics described in the Project Documents. The CxA will provide the Control System Contractor with a list of required trend log definitions to be implemented as a basis for reviewing performance during this period.
B. The Contractor will review the performance period test plan and set up the trend log definitions from the CxA. The trend data shall be provided by the contractor a comma delimited electronic file format such as CSV. If DDC system resident memory is limited or there are other issues with the trending requirements, the Contractor will notify the CxA and request the CxA redefine the test plan.
C. The performance period shall be as specified in the FPTs. If failures are encountered, the performance period shall be aborted. After corrections are made, the performance period shall be re-started at day one. Back-Charging as specified herein shall apply.

3.11 SYSTEMS MANUAL

A. The Contractor shall provide the following documents in an editable Microsoft Word Format (.doc or .docx) for use by the CxA to provide the final Systems Manual.

1. Construction record documents and specifications
2. Approved submittals
3. As-built drawings
4. As-built sequences of operation
5. Original setpoints for all commissioned systems
6. Recommended schedule for sensor recalibration
7. Equipment operation and maintenance manuals
8. Equipment preventative maintenance schedules
9. Confirmation of completed training for the Owner and Occupants

3.12 TRAINING

A. The CxA shall be notified of all training sessions held by the Contractor.
B. The training shall not occur until the system has been commissioned and proven ready for training.
C. The Contractor is responsible for scheduling and coordinating training sessions for the Owner that cover the operation of each system. Training shall occur in a classroom setting with the

appropriate schematics, handouts, and visual/audio training aids. Training shall also include demonstrations with the installed equipment and systems.

D. The Contractor shall submit training plan to the CxA at least two weeks prior to the training session. The Contractor shall provide a schedule for training times and dates. The schedule shall include location, and contact information of the instructor.
E. The training program shall include the following:

1. Emergency instructions and procedures
2. Operation instructions and procedures
3. Troubleshooting procedures
4. Maintenance and inspection procedures
5. Repair procedures
6. Upkeep of the systems manual and associated maintenance documentation logs.

F. The appropriate installing contractors shall provide training on all the major systems per specifications, including peculiarities specific to this project.
G. The equipment vendors shall provide training on the specifics of each major equipment item including philosophy, troubleshooting, and repair techniques.
H. The automatic control vendor shall provide training on the control system per their specification section.
I. The Contractor shall furnish a final video DVD set, above the owners requirements as defined elsewhere, to the CxA for their use and ownership and review. Included in those DVDs shall be the sign-in sheet for each training.

3.13 SYSTEMS ACCEPTANCE

A. Equipment and systems shall not be accepted by the Owner until all commissioning activities are complete and the performance period standards have been met.
B. Commissioning shall be completed before Substantial Completion, inclusive of functional testing, except for trend log monitoring, seasonal testing, near-warranty end activities, verification of later controls system training session, and completion of the issues log.

3.14 PROJECT CLOSEOUT

A. Post construction contractor responsibilities include completion and submission of the Project Closeout Checklist for each commissioned system to the CxA, to verify completion of contractual obligations for the owner.
B. Training on related systems and equipment operation and maintenance shall only be scheduled to commence after functional testing is satisfactorily completed, O&M manuals have been delivered and approved, and systems are verified to be 100% complete and functional. Each Contractor is responsible to provide a topical outline of all subjects to be covered in the training session(s), the expected length of time for the training sessions, and a brief resume listing the qualifications of the proposed training presenters. The CC is responsible for developing the training plan with input from the contractor and directing any videotaping efforts. The CC is responsible for coordinating training with the Owner and CxA and to verify execution of the training plan.
C. Upon request, the Contractor is responsible for providing the CxA with copies of all balancing reports, as-built drawings and O&M manuals relevant to the systems commissioned. The CxA will review this material for compliance with Project Documents and will note and report all issues for resolution by the responsible party.
D. Upon completion of all commissioning activities the CxA will prepare and submit to the owner the Final Commissioning Report detailing the commissioning plan and all commissioning activities and recommending acceptance to the Owner. The CC will support this effort by coordinating the contractor provided documentation.

3.15 WARRANTY PERIOD AND CONTINUOUS COMMISSIONING

A. The CxA shall provide continuous commissioning during the one year warranty period following substantial completion. During this time, the CxA shall adjust settings on the BAS in order to optimize the system. All issues and changes shall be communicated to the Contractor.
B. The Contractor shall resolve issues immediately.

3.16 BACK-CHARGING

A. The Contractor is responsible for scheduling and coordinating commissioning activities. The Contractor shall reimburse the owner for the cost of commissioning activities that must be repeated because of a lack of preparation or coordination by the Contractor. Reimbursable costs include CxA fees for services billed at the CxA's standard hourly rate of $186.00/Hour, mileage billed at the current IRS rate, airline and hotel fees, and the cost of any rented test equipment.
B. Repeated back-checking: Commissioning issues are documented in the issues log. The Contractor shall submit a brief written statement of when and how each issue has been resolved, using issues response forms provided by the CxA. The CxA shall back-check these issues on a one-time-per-issue basis to verify they have been resolved. If the back-checked issues that have not been resolved as reported, the associated cost of the unsuccessful back-check shall be subject to back-charging.
    1. Repeated installation verification: After the Contractor has submitted the pre-functional checklist, the CxA will perform final installation verifications on the system. Discrepancies discovered will be reported in the Commissioning Issues Log. Back-checking the correction of these discrepancies shall be subject to back-charging.
    2. Repeated witnessing of FPT demonstrations: As specified in this Section, the Contractor demonstrates the functional performance tests after they have verified that performing the FPTs will yield the documented acceptable results. The cost of witnessing demonstrations that do not demonstrate specified acceptance criteria shall be subject to back-charging.
C. Post-occupancy activities: The Contractor shall reimburse the owner for the cost of commissioning activities that occur after Certificate of Occupancy has been granted if it is due to lack of readiness by the Contractor. If commissioning must occur after hours, CxA fees for the services will be billed at an hourly rate of $244.50/Hour.

END OF SECTION

SECTION 02 4119

SELECTIVE STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Demolition and removal of selected portions of building or structure.
   2. Salvage of existing items to be reused or recycled.

B. Reference Standards:
   1. National Fire Protection Association / American National Standards Institute:
      a. NFPA 241, 'Standard for Safeguarding Construction, Alteration, and Demolition Operations', Latest Adopted Edition.
   2. American National Standards Institute / American Society of Safety Engineers:
      a. ANSI / ASSE A10.6-2006, 'Safety Requirements for Demolition Operations.'

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Storage or sale of removed items or materials will not be permitted on-site.

B. Pre-Installation Conference:
   1. Before beginning Selective Demolition work, in addition to requirements of Section 01 3100, meet on site to confirm work to be demolished, items to be salvaged or reused, and coordination with Owner.

C. Scheduling:
   1. Indicate detailed sequence of selective demolition and removal work, with starting and ending dates for each activity, on Schedule specified in Section 01 3200.

1.3 SUBMITTALS

A. Special Procedure Submittals:
   1. Inventory:
      a. After selective demolition is complete, submit list of items that have been removed and salvaged.

1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Comply with governing EPA notification regulations before beginning selective demolition.
   2. Comply with hauling and disposal regulations of authorities having jurisdiction.
   3. Standards: Comply with ANSI A10.6 and NFPA 241.

1.5 FIELD CONDITIONS

A. Existing Conditions:
   1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.

PART 2 - PRODUCTS: Not Used

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification Of Conditions:
   1. Survey existing conditions and correlate with requirements indicated to determine extent of selective demolition required.
      a. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

B. Evaluation And Assessment:
   1. Hazardous Materials:
      a. It is not expected that hazardous materials will be encountered in the Work. Identified 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 and immediately notify Architect.
   2. Inventory and record condition of items to be removed and reinstalled and items to be removed and salvaged.
   3. When unanticipated mechanical, electrical, or structural elements that conflict with intended function or design are encountered, investigate and measure nature and extent of conflict. Promptly submit written report to Architect.
   4. Perform surveys as the Work progresses to detect hazards resulting from selective demolition activities.

3.2 PREPARATION

A. Temporary Facilities:
   1. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
   2. Maintain fire-protection facilities in service during selective demolition operations.

B. Temporary Shoring:
   1. 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.
   2. Strengthen or add new supports when required during progress of selective demolition.

C. Utility Services:
   1. Existing Services/Systems: Maintain services/systems indicated to remain and protect them against damage during selective demolition operations.
   2. Service/System Requirements: Locate, identify, disconnect, and seal or cap off indicated utility services and mechanical/electrical systems serving areas to be selectively demolished.
      a. Arrange to shut off indicated utilities with utility companies.

b. If services/systems are required to be removed, relocated, or abandoned, before proceeding with selective demolition, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to other parts of building.

3.3 SELECTIVE DEMOLITION

A. General:
1. Conduct selective demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
2. 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:
   a. 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, to minimize disturbance of adjacent surfaces. Temporarily cover openings to remain.
   b. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
   c. 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 fire watch and portable fire-suppression devices during flame-cutting operations.
   d. Maintain adequate ventilation when using cutting torches.
   e. Remove decayed, vermin-infested, or otherwise dangerous or unsuitable materials and promptly dispose of off-site.
   f. Remove structural framing members and lower to ground by method suitable to avoid free fall and to prevent ground impact or dust generation.
   g. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
   h. Dispose of demolished items and materials promptly.

B. Removed and Salvaged Items:
1. Relics, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, antiques, and other items of interest or value to Owner that may be encountered during selective demolition remain Owner's property. Carefully remove and salvage each item or object in a manner to prevent damage and deliver promptly to Owner.
   a. Clean salvaged items as directed by Owner.
   b. Pack or crate items after cleaning. Identify contents of containers.
   c. Store items in a secure area until delivery to Owner.
   d. Transport items to Owner's storage area designated by Owner.
   e. Protect items from damage during transport and storage.

C. Removed and Reinstalled Items:
1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
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.

D. Existing Items to Remain:
1. Protect construction indicated to remain against damage and soiling during selective demolition.

2. When permitted by Architect, items may be removed to a suitable, protected storage location during selective demolition and cleaned and reinstalled in their original locations after selective demolition operations are complete.

3.4 CLEANING

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

B. Waste Management:
   1. Disposal of Demolished Materials:
      a. Remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill. Do not burn demolished materials.
         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.

END OF SECTION

SECTION 05 5430

SLOTTED CHANNEL FRAMING

PART I – GENERAL

1.01 SUMMARY

A. Framing shall be a strut type metal framing system (Strut System)

B. Strut System shall be used:

1. To support mechanical and electrical equipment and devices.

2. For structural applications as applicable.

C. Strut System and components must be supplied from a single approved Manufacturer.

D. Strut System shall be engineered by supplier or sub-contractor. Drawings and calculations shall be prepared and stamped by and engineer licensed in the State of Utah.

1.02 QUALITY ASSURANCE

A. Manufacturer's qualifications:

1. The manufacturer shall have at least 10 years experience in manufacturing Strut Systems.

2. The manufacturer must certify in writing all components supplied have been produced in accordance with an established quality assurance program.

B. Work shall meet the requirements of the following standards:

1. Federal, State and Local codes

2. American Iron and Steel Institute (AISI) Specification for the Design of Cold Formed Steel Structural Members 2001 Edition

3. American Society for Testing And Materials (ASTM)

4. Metal Framing Manufacturer's Association (MFMA)

1.03 SUBMITTALS

A. Structural calculations by a Registered Professional or Structural Engineer in the State of the Project's location for approval by the Professional of Record. Calculations may include, but are not limited to:

1. Description of design criteria

2. Stress and deflection analysis

3. Selection of framing members, fittings, and accessories

B. Assembly drawings necessary to install the Strut System in compliance with the Contract Drawings

C. Pertinent manufacturers published data

1.04 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. All material is to be delivered to the work site in original factory packaging to avoid damage to the finish.

B. Upon delivery to the work site, all components shall be protected from the elements by a shelter or other covering.

1.05 WARRANTY

A. Manufacturer shall warrant for 1 year from the shipment date that products will be free from defects in material or manufacture. In the event of any such defect in violation of the warranty, Manufacturer shall have the option to repair or replace any such defective product.

B. Installer shall warrant for 1 year from the date of completion of work that the work will be free of defects in installation. In the event of any such defect in violation of the warranty, Installer shall have the option to repair or replace any such defective product.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Strut System and components Basis of design is UNISTRUT®

2.02 MATERIALS

A. All channel members shall be fabricated conforming to one of the following ASTM specifications:

2. Pre-Galvanized Carbon Steel: A 653 Grade 33

B. All fittings shall be fabricated conforming to one of the following ASTM specifications:

1. Carbon Steel: All carbon steel fittings shall be fabricated from steel that meets/exceeds the physical requirements of ASTM A1011 SS Grade 33 and conforms to one of the following ASTM specifications:

a. A 575

b. A 576

c. A 36

d. A 635

e. A 1059

f. A 1046

C. Any substitutions of product or manufacturer must be approved in writing ten days prior to bid date by the Professional of Record.

2.03 FINISHES

A. PRE-GALVANIZED per ASTM A653

1. Zinc coated by hot-dipped process prior to roll forming at the steel mill

2. Zinc coating thickness shall be G90 (0.75 mil = 0.45 oz./ sq. ft. surface area)

B. HOT-DIPPED GALVANIZED per ASTM A123 or A153

1. Zinc coated after all manufacturing operations are complete

2. Zinc coating thickness shall be G65 (2.6 mils = 1.50 oz./ sq. ft. surface area)

PART 3 - EXECUTION

3.01 EXAMINATION

A. The installer shall inspect the work area prior to installation. If work area conditions are unsatisfactory, installation shall not proceed until satisfactory corrections are completed.

3.02 INSTALLATION

A. Installation shall be accomplished by a fully trained manufacturer authorized installer.

B. Set Strut System components into final position true to line, level and plumb, in accordance with approved drawings.

C. Anchor material firmly in place and tighten all connections to their recommended torques.

3.03 CLEANUP

A. Upon completion of this section of work, remove all protective wraps and debris. Repair any damage due to installation of this section of work.

3.04 PROTECTION

A. During installation, it shall be the responsibility of the installer to protect this work from damage.

B. Upon completion of this scope of work, it shall become the responsibility of the general contractor to protect this work from damage during the remainder of construction on the project and until substantial completion.

END OF SECTION

B L A N K P A G E

SECTION 07 5401

POLYVINYL-CHLORIDE ROOFING: PVC

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited to:
   1. Patch existing roofing insulation, membrane including flashings and other components to comprise total roofing system as described in Contract Documents.
   2. Modify existing concrete pavers at new roof penetrations and equipment curbs

1.2 SUBMITTALS

A. Action Submittals;
   1. Product Data: Roofing Manufacturer's literature or cut sheet for each element of system.
   2. Shop Drawings:
      a. Prepared by Roofing Manufacturer or its representative. Include outline of roof and roof size, location and type of penetrations, perimeter and penetration details, special details, and bill of materials.
      b. Confirm that specified FM Class and UL Class assembly is appropriate for Project location.
      c. Include approved copy of Manufacturers Notice of Award.

B. Informational Submittals::
   1. Test And Evaluation Reports: Submit evidence that roof system has been tested and approved or listed as follows:
      a. FM Class 1-90.
      b. UL Class A assembly.
   2. Manufacturer Instructions: Two copies of Roofing Manufacturer's published specification for Architect and maintain one at job-site.
   3. Qualification Statements: Roofing Manufacturer's certification of Installer.

C. Closeout Submittals:
   1. Operation And Maintenance Data: Submit record shop drawings to Roofing Manufacturer, if requested and include in Operation And Maintenance manuals specified in Section 01 7800. Record shop drawings shall be given shop drawing number by Roofing Manufacturer.
   2. Warranty Documentation: Include final, executed copies of warranties in Operation And Maintenance manuals specified in Section 01 7800.

1.3 QUALITY ASSURANCE

A. Qualifications:
   1. Installers:
      a. Roofing system shall be applied by Applicator authorized by Roofing Manufacturer before bid.
      b. Membrane and flashing installation shall be performed by personnel trained and authorized by Roofing Manufacturer.

c. Welding equipment shall be provided by or approved by Roofing Manufacturer. Mechanics intending to use equipment shall have successfully completed training course provided by Manufacturer's Technical Representative before welding.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products job site in original unopened containers or wrappings bearing all seals and approvals.

B. Storage And Handling Requirements:
1. Handle materials to prevent damage. Place materials on pallets and fully protect from moisture.
2. Store membrane rolls lying down on pallets fully protected from weather with clean canvas tarpaulins.
3. Do not store or use flammable adhesives vicinity of open flames, sparks, and excessive heat.
   a. Store adhesives at temperatures above 40 deg F 4 deg C.
   b. Store flammable materials in cool, dry area away from sparks and open flames. Follow precautions outlined on containers or supplied by material manufacturer/supplier.
4. Remove from job site materials that are determined to be damaged by Architect or by Roofing Manufacturer and replace at no additional cost to Owner.
5. Take precautions that storage and application of materials and equipment does not overload roof deck or building structure.

1.5 WARRANTY

A. Provide Roofing Manufacturer's standard 15-year system warranty.

B. Provide Applicator's 5-year workmanship warranty.

PART 2 - PRODUCTS

2.1 SYSTEM

A. Manufacturer:
1. Approved Manufacturer:
   a. GAF

B. Description:
1. Surface Color: Match existing white.
2. Membrane thickness: 0.80 mil thick by optimum width and length determined by job conditions.

C. Performance:
1. Design Criteria:
   a. Metal details, fabrication practices, and installation methods shall conform to applicable requirements of following:
      1) Factory Mutual Loss Prevention Data Sheet 1-49 (latest issue).
      2) Sheet Metal and Air Conditioning Contractors National Association Inc, 5th edition.

D. Materials:
1. Membrane: Spread coat manufactured, fiberglass reinforced PVC with an environmental surface coating.
2. Membrane Adhesive And Application Rates:
   a. Sarnacol 2170 Adhesive:

	Substrate	Membrane	Total

	gal/100 ft^2	gal/100 ft^2	gal/100 ft^2
Metal	0.75	0.50	1.25
Smooth plywood	1.00	0.50	1.50
Structural concrete	1.25	0.50	1.75

3. Clad flashing: 0.023 inch 0.56 mm thick G90 galvanized sheet metal laminated with 0.020 inch 0.51 mm thick Sarnafil membrane.
4. Flashing: Prefabricated expansion joint cover with foam tubing, galvanized metal nailing flanges, and membrane welding tabs.
5. Felt: Felt mat used as asphalt barrier and smoothing / leveling layer.
6. Corner: Prefabricated inside and outside corners made of membrane.
7. Reglet: Heavy aluminum flashing termination with stiffening ribs and sealant support shelf used at walls and tall curbs when counterflashings are unavailable. Reglet inside and outside corners are used to install continuous termination.
8. Bar: 14 ga 2 mm galvanized U-shaped steel bar with rolled edges and slotted holes punched one inch 25 mm on center used for membrane securement at bases of walls and curbs and as perimeter clamping bar on certain adhered roof assemblies.
9. Cord: Extruded bead of flexible PVC that is welded against side of bar when bar is used at base of wall and curbs.
10. Fastener: Self-tapping, corrosion resistant fastener used to attach insulation board or to fasten membrane at changes in slope.

2.2 ACCESSORY PRODUCTS

A. Sarnapad Walkway Pad: 1/4 inch 6 mm thick molded pad made of recycled material with welding tabs. Use left and right turns, end panels, T-panels, etc, to install continuous rooftop walkway network.

B. Recovery/Hard Board:
   1. FM or UL approved.
   2. Top Layer Over Insulation:
      a. 1/2 inch thick minimum Dens-Deck Prime Roof Board by G-P Gypsum.

C. Recovery/Hard Board Adhesive:
   1. Low rise foam adhesive.
   2. Quality Standard Products.
      a. Weathertite Adhesive by Millenium Adhesive Products Inc.
      b. Olybond 500 by Olympic Manufacturing Group (OMG).
      c. LR2001 by Sarnafil.

D. Miscellaneous Flashing Materials: As supplied by Roofing Manufacturer.

E. Miscellaneous Fasteners And Anchors:
   1. Fasteners, anchors, nails, straps, bars, etc shall be of post-galvanized zinc or cadmium-plated steel, aluminum, or stainless steel. Mixing metal types and methods of contact shall be in such a manner as to avoid galvanic corrosion.
   2. Fasteners for attachment of metal to masonry shall be expansion type fasteners with stainless steel pins.
   3. Concrete fasteners and anchors shall have minimum embedment of 1-1/4 inch 32 mm and shall be approved for such use by Fastener Manufacturer.
   4. Wood fasteners and anchors shall have embedment of one inch 25 mm minimum and be approved for such use by Fastener Manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. General:
1. Verify that roof drain lines are functioning correctly before starting work of this Section. Report blockages in writing to Owner's representative, with copy to Roofing Manufacturer, for corrective action before beginning work of this Section.
2. Remove existing roofing, base flashing, deteriorated wood blocking, and deteriorated metal flashings. Remove only that amount of existing roofing and flashing that can be made watertight with new materials during a one day period or onset of inclement weather.
3. Remove existing roofing membrane in such a manner to use for base flashing.
4. Stop work immediately if any unusual or concealed condition is discovered and immediately notify Owner in writing, with letter copy to Roofing Manufacturer.

B. Substrate shall be clean, smooth, dry, free of flaws, sharp edges, loose and foreign material, oil and grease. Roofing shall not start until defects have been corrected.

3.2 INSTALLATION

A. General:
1. Roof surfaces shall be free of water, ice and snow. Surfaces to receive new insulation, membrane, or flashings shall be dry. Should surface moisture occur, provide equipment necessary to dry surface before application.
2. Secure new and temporary construction, including equipment and accessories, so as to preclude wind blow-off and subsequent roof or equipment damage.
3. Install only as much roofing as can be made weathertight each day, including flashing and detail work. Clean seams and heat-weld before leaving jobsite.
4. Schedule and execute work without exposing interior building areas to effects of inclement weather. Protect existing building and its contents against all risks.
5. Install uninterrupted waterstops at end of each day's work and completely remove before proceeding with next day's work. Waterstops shall not emit dangerous or unsafe fumes and shall not remain in contact with finished roof as installation progresses. Replace contaminated membrane at no additional cost to Owner.
6. Avoid use of newly constructed roofing as walking surface or for equipment movement and storage. Where such access is required, provide necessary protection and barriers to segregate work area and to prevent damage to adjacent areas. Provide protection layer consisting of plywood over insulation board and roofing membrane for new and existing roof areas that receive rooftop traffic during construction.
7. Before and during application, remove dirt, debris, and dust from surfaces either by vacuuming, sweeping, blowing with compressed air, or similar methods.
8. Report rooftop contamination that is anticipated or that is occurring to Roofing Manufacturer to determine corrective steps to be taken.

B. Membrane:
1. Inspect surface of insulation or substrate before installation of roof membrane. Substrate shall be clean, dry and smooth with no excessive surface roughness, contaminated surfaces or unsound surfaces such as broken, delaminated, or damaged insulation boards.
2. Adhesive:
   a. Apply adhesive using solvent-resistant 3/4 inch 19 mm nap paint rollers. Apply adhesive in smooth, even coating with no holidays, globs, puddles, or similar irregularities. Coat only area that can be completely covered in same day's operations with adhesive. Allow adhesive to dry completely prior to installing membrane.

b. When adhesive on substrate is dry, roof membrane is unrolled. Overlap adjacent sheets 3 inches 75 mm. Once in place, turn back one-half of sheet's length and coat underside adhesive at rate of 1/2 gal per 100 sq ft 2 liters per 9 sq meters. When adhesive has dried sufficiently to produce strings when touched with dry finger, roll coated membrane onto previously coated substrate being careful to avoid wrinkles. Do not allow adhesive on underside of membrane to dry completely. Amount of membrane that can be coated with adhesive before rolling into substrate will be determined by ambient temperature, humidity, and manpower. Press bonded sheet firmly in place with weighted foam-covered lawn roller by frequent rolling in two directions. Fold back remaining unbonded half of sheet and repeat procedure.

c. Apply no adhesive in seam areas.

3. Hot-Air Welding Of Lap Areas:

a. General:

1) Seams shall be hot air welded. Seam overlaps shall be 3 inches 75 mm wide minimum when automatic machine welding, and 4 inches 100 mm wide when hand welding.

2) Membrane to be welded shall be clean and dry. No adhesive shall be in seam.

b. Hand Welding:

1) Hand welded seams shall be completed in three stages. Allow hot-air welding equipment to warm up for one minute minimum before welding.

2) Seam shall be tack-welded every 36 inches 900 mm to hold membrane in place.

3) Weld back edge of seam with narrow but continuous weld to prevent loss of hot air during final welding.

4) Insert nozzle into seam at 45-degree angle. Once proper welding temperature has been reached and membrane begins to 'flow', position hand roller perpendicular to nozzle and press lightly. For straight seams, use 1-1/2 inch 38 mm wide nozzle. Use 3/4 inch 19 mm wide nozzle for corners and compound connections.

c. Machine Welding: Follow Roofing Manufacturer's instructions and use recommended equipment.

d. Quality Control of Welded Seams: Check welded seams for continuity using rounded screwdriver. Make on-site evaluation of welded seams daily at locations directed by Owner's Representative or representative of Roofing Manufacturer. Take one inch 25 mm wide cross-section samples of welded seams at least three times a day. Patch each test cut at no additional cost to Owner.

C. Flashings:

1. General:

a. Install flashings concurrently with roof membrane as job progresses. No temporary flashings shall be allowed without prior written approval of Owner's Representative and Roofing Manufacturer. Approval shall only be for specific locations on specific dates.

b. If water is allowed to enter under newly completed roofing, remove and replace affected area no additional cost to Owner.

c. Adhere flashings to compatible, dry, smooth, and solvent-resistant surfaces.

2. Membrane Flashings:

a. Adhesive Application for Flashings:

1) Apply adhesive using solvent-resistant 3/4 inch 19 mm nap paint rollers. Apply adhesive in smooth, even coatings with no holidays, globs, or similar irregularities. Coat only area that can be completely covered in same day's operations. Allow surface with adhesive coating to dry completely prior to installing flashing membrane.

2) When surface is dry, cut flashing membrane to workable length and evenly coat underside with adhesive at rate of 1/2 gal per 100 sq ft 2 liters per 9 sq meters. When adhesive has dried sufficiently to produce strings when touched with a dry finger, roll coated membrane onto previously coated substrate being careful to avoid wrinkles. Do not allow adhesive on underside of membrane to completely dry. Overlap adjacent sheets 3 inches 75 mm. Flashings shall extend 4 inches 100 mm onto roofing membrane. Press bonded sheet firmly in place with hand roller.

3) Apply no adhesive in seam areas that are to be welded.

b. Install Sarnastop fastened 12 inches 300 mm on center with acceptable fasteners into structural deck at the base of parapets, walls, and curbs. Also install Sarnastop at the base of tapered edge strips and at transitions, peaks, and valleys according to Roofing Manufacturer's details.
c. Extend flashings 8 inches 200 mm minimum above roofing level unless otherwise accepted in writing by Owner's representative and Roofing Manufacturer.
d. Adhere flashing membranes to solvent resistant substrates. Cut interior and exterior corners and miters and hot-air weld into place. No bitumen shall be in contact with membrane.
e. Mechanically fasten flashing membranes along top edge through tin discs or pre-drilled, galvanized metal strip washers spaced at of 12 inches 300 mm maximum on center.
f. Terminate flashings according to Roofing Manufacturer's recommended details.

3. Metal Flashings:
   a. Complete metal work in conjunction with roofing and flashings so that watertight condition exists daily.
   b. Install metal to provide adequate resistance to bending and allow for normal thermal expansion and contraction.
   c. Metal joints shall be watertight.
   d. Securely fasten metal flashings into solid wood blocking. Fasteners shall penetrate wood nailer one inch 25 mm minimum.
   e. Airtight and continuous metal hook strips are required behind metal fascias. Fasten hook strips 12 inches 300 mm on center into wood nailer or masonry wall.
   f. Counterflashings shall overlap base flashings 4 inches 100 mm minimum.
   g. Sarnaclad Metal Base Flashings: Space adjacent sheets of Sarnaclad 1/4 inch 6 mm apart. Fasten ends of Sarnaclad metal 6 inches 150 mm on center. Cover joint with 2 inch 50 mm wide aluminum tape. Hot-air weld 4 inch 100 mm wide strip of flashing membrane over joint.
   h. Sarnaclad Metal Edge Flashing: Fasten metal edge flashings with two rows of post-galvanized flat head annular ring nails, 4 inches 100 mm on center staggered. Space adjacent sheets of Sarnaclad metal 1/4 inch 6 mm apart. Cover joint with 2 inch 50 mm wide aluminum tape. Hot-air weld 4 inch 100 mm wide strip of flashing membrane over joint.

3.3 FIELD QUALITY CONTROL

A. Field Inspections: Upon completion of installation and delivery to Roofing Manufacturer by Applicator of certification that installation has been performed in accordance with Contract Documents and Roofing Manufacturer's requirements, technical representative of Roofing Manufacturer shall inspect installed roofing system.

3.4 CLEANING

A. Remove demolished material from site daily to legal dumping area legally authorized to receive such materials.

B. Remove roofing waste material from site daily to legal dumping area authorized to receive such material.

C. Site cleanup, including both interior and exterior building areas that have been affected by construction, shall be completed to Owner's satisfaction.

D. Repair landscaped areas damaged by construction activities at no additional cost to Owner.

END OF SECTION

SECTION 07 8400

FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install all code required firestopping involving penetrations whether or not described in Contract Documents.
   2. Quality of firestopping materials and systems used for penetrations on Project, including submittal requirements.

B. Related Requirements:
   1. Furnishing and installing of penetration firestopping specified under Section installing work penetrating structure.

1.2 REFERENCES

A. Definitions:
   1. Annular space: Opening around a penetrating item.
   2. Exposed Penetration Firestopping: Products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.
   3. F Rating: The time period that the through-penetration flrestop system limits the spread of fire through the penetration when tested in accordance with ASTM E 814 or UL 1479.
   4. Fire-Resistant Joint System: An assemblage of specific materials or products that are designed, tested and fire-resistance rated in accordance with either ASTM E 1966 or UL 2079 to resist for a prescribed period of time the passage of fire through joints made in or between fire-resistance-rated assemblies.
   5. Firestopping: A process whereby certain materials, some of them specially manufactured, are used to resist (or stop) the spread of fire and its byproducts through openings made to accommodate penetrations in fire-rated walls, floors and floor/ceiling assemblies.
   6. Joint: The linear opening in or between adjacent fire-resistance-rated assemblies that is designed to allow independent movement of the building in any plane caused by thermal, seismic, wind or any other loading.
   7. Membrane Penetration: An opening made through one side (wall, floor or ceiling membrane) of an assembly.
   8. Membrane-Penetration Firestop: A material, device or construction installed to resist for a prescribed time period the passage of flame and heat through openings in a protective membrane in order to accommodate cables, cable trays, conduit, tubing, pipes or similar items.
   9. Penetration - An opening created in a membrane or assembly to accommodate penetrating items for electrical, mechanical, environmental, and communication systems.
   10. Penetration Firestop System:
      a. A specific construction consisting of materials that protect the opening around the penetrating items to resist spread of fire and passage of smoke and other gases to resist passage of fire through penetrations for prescribed period of time. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any. Tested in accordance with ASTM E 814 or UL 1479.
   11. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg (2.49 Pa).

a. Fire-resistance-rated walls include, fire walls, fire-barrier walls, smoke-barrier walls, and fire partitions.
b. F-Rating: Not less than the fire-resistance rating of constructions penetrated.

12. Penetrations in Horizontal Assemblies: Penetration firestopping with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg (2.49 Pa).
    a. a. Horizontal assemblies include [floors] [floor/ceiling assemblies] [and] [ceiling membranes of the following:
        1) F-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated.
        2) T-Rating: At least 1 hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.
13. Penetrations in Smoke Barriers: Penetration firestopping with ratings determined per UL 1479.
    a. L-Rating: Not exceeding 5.0 cfm/sq. ft. (0.025 cu. m/s per sq. m) of penetration opening at 0.30-inch wg (74.7 Pa) at both ambient and elevated temperatures.
14. T Rating: The time period that the penetration firestop system, including the penetrating item, limits the maximum temperature rise to 325 deg F (163 deg C) above its initial temperature through the penetration on the nonfire side when tested in accordance with ASTM E 814 or UL 1479.
15. Through Penetration: An opening that passes through an entire assembly.
16. Through-Penetration Firestop System: An assemblage of specific materials or products that are designed, tested and fire-resistance rated to resist for a prescribed period of time the spread of fire through penetrations. The F and T rating criteria for penetration firestop systems shall be in accordance with ASTME 814 or UL 1479. See definitions of "F Rating" and "T Rating."
17. W-Rating: Penetration firestopping showing no evidence of water leakage when tested according to UL 1479.

B. Reference Standards:
1. American Society For Testing And Materials:
    a. ASTM E84-10, ‘Standard Test Method for Surface Burning Characteristics of Building Materials.’
    b. ASTM E814-09, ‘Standard Test Method for Fire Tests of Penetration Firestop Systems.’
2. International Building Code (ICC):
    a. Chapter 7 - Fire-Resistance-Rated Construction.
3. International Conference of Building Officials:
    a. ICBO, 'Uniform Building Code (UBC), Volume 1, Administrative, Fire and Life Safety, and Field Inspection Provisions.'
4. Underwriter's Laboratories / American National Standards Institute:
    a. UL / ANSI 1479-2003, 'Standard for Safety for Fire Tests of Through-Penetration Firestops.'
    b. Fire Resistance Directory, current edition, contains listing of approved Penetration Firestop Systems.

1.3 SUBMITTALS

A. Action Submittals:
1. Shop Drawings:
    a. Show each type of Penetration Firestop System to be used on Project with design approval reference number.
    b. Identify locations where each type of Penetration Firestop System is to be installed.

1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:

1. Each Penetration Firestop System shall be UL / ULC listed for that type of penetration occurring on Project.
2. Ratings shall be in accordance with ASTM E814, UL 1479, IBC Section 713, or UBC Standard No 43-6 as acceptable to local code authority.

B. Qualifications:
1. Installers of firestopping at penetrations larger than 4 inch diameter:
   a. Installer who is certified and licensed or qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products per specified requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage And Handling Requirements:
1. Deliver firestopping materials to the Site in original, new unopened containers or packages bearing manufacturer's printed labels.

B. Storage And Handling Requirements:
1. Store and handle firestopping materials to prevent deterioration or damage due to moisture, temperature changes, contaminants or other causes.

1.6 FIELD CONDITIONS

A. Ambient Conditions:
1. Temperature: Do not install firestopping materials when ambient or substrate temperatures are outside limits permitted by manufacturer of firestopping materials.
2. Humidity and Moisture: Do not install the Work of this Section under conditions that are detrimental to the application, curing, and performance of the materials.
3. Ventilation: Provide sufficient ventilation wherever firestopping materials are installed in enclosed spaces. Follow manufacturer's recommendations.

PART 2 - PRODUCTS

2.1 SYSTEMS

A. Manufacturers:
1. Type Two Acceptable Manufacturers:
   a. Members of International Firestop Council www.firestop.org.
   b. Equal as approved by Architect before installation. See Section 01 6200.

B. Materials:
1. Sealant, packing material, or collar system required by Firestop Manufacturer for Firestop Penetration System to comply with listed design.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification Of Conditions:

1. Examine areas and conditions under which work is to be performed and identify conditions detrimental to proper or timely completion.
2. Surfaces to which firestop materials will be applied shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellents, and any other substances that may inhibit optimum adhesion.
3. Do not commence Work until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Clean out openings, control, and expansion joints immediately before installation of through-penetration firestopping. Comply with recommendations of firestopping manufacturer and the following requirements:
   1. Remove foreign materials from surfaces of openings and joint substrates, and from penetrating items that could interfere with adhesion of firestopping.
   2. Clean opening and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
   3. Remove laitance and form release agents from concrete.
   4. Provide masking and temporary covering to prevent soiling of adjacent surfaces by firestopping materials.

3.3 INSTALLATION

A. General: Install firestopping in accordance with Manufacturer's instructions for installation of firestopping products.

3.4 PROTECTION

A. Protect surfaces adjacent to through-penetration firestops with suitable covering to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of Work and that would otherwise be permanently stained or damaged by such contact or that would be caused by cleaning methods used to remove smears from firestopping materials.

3.5 CLEANING

A. Clean off excess fill materials and sealants adjacent to penetrations by methods and cleaning materials recommended by manufacturers of firestopping products and of products in which penetrations occur.

B. Protect firestopping during and after curing period from contact with contaminating substances, or damage resulting from adjacent Work.

END OF SECTION

SECTION 07 9213

ELASTOMERIC JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install sealants not specified to be furnished and installed under other Sections.
   2. Quality of sealants to be used on Project not specified elsewhere, including submittal, material, and installation requirements.

B. Related Requirements:
   Furnishing and installing of sealants is specified in Sections specifying work to receive new sealants.

1.2 REFERENCES

A. Definitions:
   1. Adhesive: An adhesive, as defined by The American Society for Testing and Materials (ASTM), is “a substance capable of holding materials together by surface attachment“
   2. Caulk: Caulks have a variety of definitions but are generally recognized as materials used in applications where only minor elastomeric properties are needed.
   3. Sealant. Sealants are generally used in applications where elastic properties are needed while adhesives are generally used in applications where bonding strength and rigidity are needed. With technology advancements both sealants and adhesives can be used interchangeably depending on the applications performance requirements.

B. Association Publications:
   1. American Architectural Manufacturers Association (AAMA):
      a. “Voluntary Specifications and Test Methods for Sealants”.
   2. ASM International:
      a. “Adhesives and Sealants”, Volume 3, ASM International Handbook Committee, May 1999.
      b. Committee C24 on Building Seals and Sealants for various Specifications, Guides, Test Methods, and Practices related to sealant specifying and application.
      c. Committee E6 on Building Performance for various Specifications, Guides, Test Methods, and Practices related to sealant use with air barriers, vapor retarders, and exterior enclosure systems and materials.
   3. The Adhesive and Sealing Council, Inc. (ASC) / Sealant, Waterproofing & Restoration Institute (SWR Institute):
      a. “Sealants: The Professional’s Guide”.
      b. “Joint Sealants”, Whole Building Design Guide”.

C. Reference Standards:
   1. ASTM International:
      a. ASTM C920-08, ‘Standard Specification for Elastomeric Joint Sealants.'
      b. ASTM C1193-09, ‘Standard Guide for Use of Joint Sealants.’

1.3 ADMINISTRATIVE REQUIREMENTS

A. Scheduling:
   1. Schedule work so waterproofing, water repellents and preservative finishes are installed after sealants, unless sealant manufacturer approves otherwise in writing.
   2. Ensure sealants are cured before covering with other materials.

1.4 SUBMITTALS

A. Action Submittals:
   1. Product Data:
      a. Manufacturer's specifications and other data needed to prove compliance with the specified requirements.
      b. Manufacturer's literature for each Product, including color charts.
      c. Schedule showing joints requiring sealants. Show also backing and primer to be used.

B. Informational Submittals:
   1. Certificates:
      a. Manufacturer's Certificate:
         1) Certify products are suitable for intended use and products meet or exceed specified requirements.
         2) Certificate from Manufacturer indicating date of manufacture.
   2. Manufacturers' Instructions:
      a. Manufacturer's installation recommendations for each Product.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements:
   1. Deliver and keep in original containers until ready for use.

B. Storage and Handling Requirements:
   1. Handle to prevent inclusion of foreign matter, damage by water, or breakage.
   2. Store in a cool dry location, but never under 40 deg F (4 deg C).

1.6 FIELD CONDITIONS

A. Ambient Conditions:
   1. Do not install sealant during inclement weather or when such conditions are expected. Allow wet surfaces to dry.
   2. Follow Manufacturer's temperature recommendations for installing sealants.

1.7 WARRANTY

A. Manufacturer Warranty:
   1. Manufacturer's standard warranty covering sealant materials.

PART 2 - PRODUCTS

2.1 SYSTEMS

A. Manufacturers:
   1. Manufacturer Contact List:
      a. Dow Corning Corp, Midland, MI www.dowcorning.com.
      b. GE Sealants & Adhesives, Huntersville, NC www.gesealants.com or G E Silicone Canada, Mississauga, ON (905) 858-6744 or (800) 668-4644.
      c. Laticrete International Inc, Bethany, CT www.laticrete.com.
      d. Sherwin-Williams, Cleveland, OH www.sherwin-williams.com.
      e. Sika Corporation, Lyndhurst, NJ www.sikaconstruction.com or Sika Canada Inc, Pointe Claire, QC www.sika.ca.
      f. Tremco, Beachwood, OH www.tremcosealants.com or Tremco Ltd, Toronto, ON (800) 363-3213.

B. Materials:
   1. General:
      a. Sealants provided shall meet Manufacturer's shelf-life requirements.
      b. Sealants must adhere to and be compatible with specified substrates.
      c. Primers, if required, shall not stain and shall be compatible with substrates.
      d. Sealants shall be stable when exposed to UV, joint movements, and particular environment prevailing at project location.
      e. Sealant shall be a formulation meeting the performance requirements of ASTM C 920.
   2. General Interior Sealants:
      a. All joints or gaps between substrates and materials.
      b. Paintable sealant:
         1) Approved Product.
            a) GE Silicone II XST.
      c. Non-Paintable sealant:
         1) Approved Product.
            a) Tub, Tile, And Ceramic Silicone Sealant by Dow Corning.
            b) GE Silicone II - Window and Door with BioSeal.
            c) Latasil Silicone Sealant by Laticrete.
            d) Pro-Select Kitchen And Bath Silicone Sealant by Sherwin Williams.
            e) Tremsil 200 Silicone Sealant by Tremco.
   3. Color: As selected by Architect from Manufacturer's standard colors.

2.2 ACCESSORIES

A. Backing:
   1. Flexible closed cell, non-gassing polyurethane or polyolefin rod or bond breaker tape as recommended by Sealant Manufacturer for joints being sealed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Apply primer, if required.

B. Joint Backing:
   1. Prepare joints in accordance with ASTM C1193.

2. Clean concrete joint surfaces to remove dirt, dust, oils, paints, curing agents and form release agents.
3. Rod for open joints shall be at least 1-1/2 times width of open joint and of thickness to give solid backing. Backing shall fill up joint so depth of sealant bite is no more than 3/8 inch (9.5 mm) deep.
4. Apply bond-breaker tape in shallow joints as recommended by Sealant Manufacturer.

3.2 APPLICATION

A. Do not use damaged or deteriorated materials.

B. Apply sealant with hand-caulking gun with nozzle of proper size to fit joints. Use sufficient pressure to insure full contact to both sides of joint to full depth of joint. Apply sealants in vertical joints from bottom to top.

C. Tool joints immediately after application of sealant if required to achieve full bedding to substrate or to achieve smooth sealant surface. Tool joints in opposite direction from application direction, i.e., in vertical joints, from the top down. Do not 'wet tool' sealants.

D. Depth of sealant bite shall be 1/4 inch (6 mm) minimum and 1/2 inch (12.7 mm) maximum, but never more than one half or less than one fourth joint width.

E. Do not apply caulking at temperatures below 40 deg F (4 deg C).

F. Caulk all gaps between painted or coated substrates and unfinished or pre-finished substrates, except where directed otherwise by architect. Caulk all gaps between painted or coated substrates, except where directed otherwise by architect.

3.3 CLEANING

A. Clean adjacent materials, which have been soiled, immediately (before setting) as recommended by Manufacturer.

END OF SECTION

SECTION 09 2226

METAL SUSPENSION SYSTEM: GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install ceiling suspension systems as described in Contract Documents to receive gypsum board and to support items penetrating ceiling.
   2. Carefully remove, store, and re-install ceiling suspensions systems as described in Contract Documents to receive gypsum board and to support items penetrating ceiling.

1.2 REFERENCES

A. Association Publications:
   1. The Ceilings & Interior Systems Construction Association (CISCA), *Ceiling Systems Handbook*. 405 Illinois Avenue, 2B, St Charles IL. www.cisca.org.

B. Reference Standards:
   1. American Society of Civil Engineers:
      a. ASCE / SEI 7-05 (Supplement No. 2), 'Minimum Design Loads for Buildings and Other Structures.'
   2. ASTM International:
      a. ASTM C635 / C635M-07, 'Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.'
      b. ASTM C636 / C636M-08, 'Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.'
      c. ASTM E580 / E580M-09, 'Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions.'
   3. International Code Council (IBC):
      a. IBC 803.9.1.1, 'Suspended Acoustical Ceiling.'

1.3 SUBMITTALS

A. Informational Submittals:
   1. Manufacturer's Instructions:
      a. Manufacturer's details and installation instructions for seismic bracing. If requested, provide copy of code requirements applicable to Project.

1.4 QUALITY ASSURANCE

A. Regulatory Agency Sustainability Approvals:
   1. Meet seismic bracing requirements of ASCE 7-05, ASTM C635 and ASTM C636 or equivalent governing standard for project site.

PART 2 - PRODUCTS

2.1 SYSTEMS

A. Manufacturers:
   1. Type One Acceptable Systems:
      a. Drywall Grid by Armstrong World Industries, Lancaster, PA www.armstrong.com.
      b. Drywall Furring Suspended Ceiling System by Chicago Metallic Corporation, Chicago, IL www.chicagometallic.com.
      c. Drywall Suspension System by USG, Chicago, IL www.usg.com.
      d. Equal as approved by Architect before bidding. See Section 01 6200.

B. Miscellaneous Materials:
   1. Hanger Wire: 12 ga (2.6 mm) minimum galvanized carbon steel, soft tempered, pre-stretched unless thicker required by ceiling loading in accordance with Suspension System Manufacturer's Literature.
   2. Joint Wire: 16 ga (1.6 mm) galvanized for joints.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow Manufacturer's instructions with modifications listed below, except where Manufacturer's instructions are more stringent.
   1. Main runners hanger wires 48 inches (1 200 mm) on center maximum.
   2. Cross runners hanger wires 24 inches (600 mm) on center maximum.
   3. Maintain flatness of assembly to within 1/8 inch (3 mm) in 12 feet (3.600 meters).
   4. Do not kink, twist, or bend hanger wires as a means of leveling assembly.

END OF SECTION

SECTION 09 2900

GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Furnish and install gypsum board as described in Contract Documents.

1.2 REFERENCES

A. Definitions:
   1. Accessories: Metal or plastic beads, trim, or moulding used to protect or conceal corners, edges, or abutments of the gypsum board construction.
   2. Drywall Primer: Paint material specifically formulated to fill the pores and equalize the suction difference between gypsum board surface paper and the compound used on finished joints, angles, fastener heads, and accessories and over skim coatings.
   3. Skim Coat: Either a thin coat of joint compound trowel applied, or a material manufactured especially for this purpose and applied in accordance with manufacturer's recommendations, over the entire surface.
   4. Texturing: Regular or irregular patterns typically produced by applying a mixture of joint compound and water, or proprietary texture materials including latex base texture paint, to a gypsum board surface previously coated with drywall primer.

B. Reference Standards:
   1. ASTM International:
      a. ASTM C11-10, 'Standard Terminology Relating to Gypsum and Related Building Materials and Systems.'
      b. ASTM C475/C475M-02(2007), 'Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board.'
      c. ASTM C840-08, 'Standard Specification for Application and Finishing of Gypsum Board.'
      d. ASTM C1002-07, 'Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs.'
      e. ASTM C1047-10, 'Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base.'
      f. ASTM C1178/C1178M-08, 'Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel.'
      g. ASTM C1396/C1396M-09a, 'Standard Specification for Gypsum Board.'
      h. ASTM E84-10, 'Standard Test Method for Surface Burning Characteristics of Building Materials.'
         ASTM E90-09, 'Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.'
      i. ASTM E119-10a, 'Standard Test Method for Fire Tests of Building Construction and Materials.'
      j. ASTM E413-04, 'Classification for Rating Sound Insulation.'
   2. Gypsum Association:
      a. GA-214-07e, 'Recommended Levels of Gypsum Board Finish.'
      b. GA-216-07: 'Application and Finishing of Gypsum Panel Products.'
      c. GA-600-09, 'Fire Reference Design Manual.'

d. GA-801-07, 'Handling and Storage of Gypsum Panel Products: A Guide for Distributors, Retailers, and Contractors.'

3. Underwriters Laboratories, Inc.
   a. UL 263: 'Test Method for Fire Tests of Building Construction and Materials.'
   b. UL 723: 'Standard for Safety Test for Surface Burning Characteristics of Building Materials; Tenth Edition September 10 2008.'

1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-Installation Conference:
   1. Schedule pre-installation conference immediately before installation of gypsum wallboard.
   2. In addition to agenda items specified in Section 01 3100, review following:
      a. Finish requirements necessary for installation of finish materials over gypsum wallboard.
   3. Review each location for scope and extent of work and protection of surrounding space.

1.4 SUBMITTALS

A. Informational Submittals:
   1. Test And Evaluation Reports:
      a. Fire test results or assembly diagrams and numbers confirming products used will provide required fire ratings with installation configurations used.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General:
   1. Following recommendations of GA-801 Guide for Handling and Storage of Gypsum Panel Products unless local, state or federal laws or agency rules differing from the recommendations shall take precedence.

B. Delivery And Acceptance Requirements:
   1. Deliver materials in original packages, containers, or bundles bearing brand name, applicable standard designation, and Manufacturer's name.

C. Storage And Handling Requirements:
   1. Store material under roof and keep dry and protected against damage from weather, condensation, direct sunlight, construction traffic, and other causes. Stack gypsum board flat to prevent sagging.

1.6 FIELD CONDITIONS

A. Ambient Conditions:
   1. Comply with ASTM C840 or GA-216 requirements, whichever are more stringent:
      a. Do not install interior products until installation areas are enclosed and conditioned.
         1) Temperature shall be 50 deg F (10 deg C) and 95 deg F (35 deg C) maximum day and night during entire joint operation and until execution of Certificate of Substantial Completion.
         2) Provide ventilation to eliminate excessive moisture.
         3) Avoid hot air drafts that will cause too rapid drying.
      b. Do not install panels that are wet, those that are moisture damaged, and those that are mold damaged.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Manufacturers:
1. Manufacturer Contact List:
   a. American Gypsum, Dallas, TX www.americangypsum.com.
   b. CertainTeed Gypsum, Inc; Tampa, FL www.certainteed.com.
   c. Georgia Pacific, Atlanta, GA www.gp.com.
   d. National Gypsum, Charlotte, NC www.nationalgypsum.com.
   e. Pabco Gypsum, Newark, CA www.pabcogypsum.com.
   f. United States Gypsum Co, Chicago, IL www.usg.com.

B. Materials:
1. Interior Gypsum Board – behind casework:
   a. General:
      1) Size:
         a) Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.
      2) Class Two Quality Standard:
         a) Core: Fire-resistant rated gypsum core.
         b) Complies with Type X requirements of ASTM C1396/C1396M (Section 5).
         c) Surface paper: Face paper suitable for painting.
         d) Long edges: Tapered edge.
         e) Overall thickness: 5/8 inch (15.9 mm).

2.2 ACCESSORIES

A. Manufacturers:
1. Manufacturer Contact List:
   a. FryReglet
   b. Kinetics Noise Control, Dublin, OH www.kineticsnoise.com.
   c. Magnum Products, Lenaxa, KS www.levelcoat.com.
   d. National Gypsum, Charlotte, NC www.nationalgypsum.com.
   e. Soundproofing Co, San Marcos, CA www.soundproofing.org.
   f. United States Gypsum Co, Chicago, IL www.usg.com.
   g. Westpac Materials Inc, Orange, CA www.westpacmaterials.com.
   h. Wm. Zinsser & Co, Somerset, NJ www.zinsser.com.
2. Gypsum Board Mounting Accessories:
   a. Quality Standards.
      1) Furring Channels:
         a) Walls: Galvanized DWFC-25.
         b) Ceilings: Galvanized DWFC-20.
      2) Accessories as required by Manufacturer's fire tests to provide necessary fire ratings.
3. Corner And Edge Trim:
   a. Metal, paper-faced metal, paper-faced plastic, or solid vinyl meeting requirements of ASTM C1047. Surfaces to receive bedding cement treated for maximum bonding.
   b. Aluminum reveal molding – color to match existing window frames
      1) Design Standard Product – Fry Reglet DRMZ 625-75
   c. Aluminum closure trim - color to match existing window frames
      1) Aluminum break metal.
4. Joint Compound:

a. Best grade or type recommended by Board Manufacturer and meeting requirements of ASTM C475/C475M.
   1) Use Taping Compound for first coat to embed tape and accessories.
   2) Use Taping Compound or All-Purpose Compound for subsequent coats except final coat.
   3) Use Finishing Compound for final coat and for skim coat.

5. Joint Reinforcing:
   a. Paper reinforcing tape acceptable to Gypsum Board Manufacturer.
6. Fasteners:
   a. Bugle head screws meeting requirements of ASTM C1002:
      1) Gypsum Board:
         a) Type S: For fastening gypsum board to steel framing and ceiling suspension members, of length to penetrate steel framing 3/8 inch (9.5 mm) minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification Of Conditions:
   1. Examine substrate and verify framing is suitable for installation of gypsum board.
   2. Examine gypsum board before installation. Reject panels that are wet, moisture damaged, and mold damaged.
   3. Notify Architect of unsuitable conditions in writing.
      a. Do not install board over unsuitable conditions.
   4. Commencement of Work by installer is considered acceptance of substrate.

3.2 INSTALLATION

A. Interface With Other Work:
   1. Coordinate with Division 06 for location of backblocking for edges and ends of gypsum board and for blocking required for installation of equipment and building specialties.
   2. Do not install gypsum board until required blocking is in place.

B. General: Install and finish as recommended in ASTM C840 or GA-216 unless specified otherwise in this Section.

C. Interior Gypsum Board:
   1. General:
      a. Install so trim and reinforcing tape are fully backed by gypsum board. No hollow spaces between pieces of gypsum board over 1/8 inch (3 mm) wide before taping are acceptable.
      b. Rout out backside of gypsum board to accommodate items that extend beyond face of framing, but do not penetrate face of gypsum board, such as metal door frame mounting brackets, etc.
   2. Single Layer Application:
      a. Apply ceilings first using minimum of two men.
      b. Use board of length to give minimum number of joints.
      c. On walls over 108 inches (2 700 mm) high and on ceilings, apply board perpendicular to support.
      d. Stagger end joints. End and edge joints of board applied on ceilings shall occur over framing members or be back blocked with 2x4 (38 mm by 89 mm) blocking. End joints of board horizontally applied on walls shall occur over framing members. Edge joints of board vertically applied on walls shall occur over framing members.

e. Butt edges in moderate contact. Do not force in place. Shim to level.
f. Leave facings true with joint, finishing flush. Vertical work shall be plumb and ceiling surfaces level.
g. Scribe work closely. Keep joints as far from openings as possible. If joints occur near an opening, apply board so vertical joints are centered over openings. No vertical joints shall occur within 8 inches (200 mm) of external corners or openings.
h. Install board tight against support with joints even and true. Tighten loose screws.
i. Caulk perimeter joints in sound insulated rooms with specified acoustical sealant.

3. Fastening:
   a. Apply from center of board towards ends and edges.
   b. Apply screws 3/8 inch (9.5 mm) minimum from ends and edges, one inch (25 mm) maximum from edges, and 1/2 inch (13 mm) maximum from ends.
   c. Spacing:
      1) Ends: Screws not over 7 inches (175 mm) on center at edges where blocking or framing occurs.
      2) Wood Framed Walls And Ceilings: Screws 7 inches (175 mm) on center in panel field.
      3) Metal Framed Walls: Screws 12 inches (300 mm) on center in panel field.
   d. Set screw heads 1/32 inch (0.8 mm) below plane of board, but do not break face paper. If face is accidentally broken, apply additional screw 2 inches (50 mm) away.
   e. Screws on adjacent ends or edges shall be opposite each other.
   f. Drive screws with shank perpendicular to face of board.
4. Trim:
   a. Corner Beads:
      1) Attach corner beads to outside corners.
         a) Attach metal corner bead with staples spaced 4 inches (100 mm) on center maximum and flat taped over edges of corner bead. Also, apply screw through edge of corner bead where wood trim will overlay corner bead.
         b) Set paper-faced trim in solid bed of taping compound.
   b. Edge Trim: Apply where gypsum board abuts dissimilar material. Hold channel and 'L' trim back from exterior window and door frames 1/8 inch (3 mm) to allow for caulking.
5. Finishing:
   a. General:
      1) Tape and finish joints and corners throughout building as specified below to correspond with final finish material to be applied to gypsum board. When sanding, do not raise nap of gypsum board face paper or paper-faced trim.
      2) First Coat:
         a) Apply tape over center of joint in complete, uniform bed of specified taping compound and wipe with a joint knife leaving a thin coating of joint compound. If metal corner bead is used, apply reinforcing tape over flange of metal corner bead and trim so half of tape width is on flange and half is on gypsum board.
         b) Completely fill gouges, dents, and fastener dimples.
         c) Allow to dry and sand lightly if necessary to eliminate high spots or excessive compound.
      3) Second Coat:
         a) Apply coat of specified joint compound over embedded tape extending 3-1/2 inches (88 mm) on both sides of joint center. Use finishing compound only if applied coat is intended as final coat.
         b) Re-coat gouges, dents, and fastener dimples.
         c) Allow to dry and sand lightly to eliminate high spots or excessive compound.
      4) Third Coat: Apply same as second coat except extend application 6 inches (150 mm) on both sides of joint center. Allow to dry and sand with fine sandpaper or wipe with damp sponge.
      5) Fourth Coat: Apply same as second coat except extend application 9 inches (425 mm) on both sides of joint center. Allow to dry and sand with fine sandpaper or wipe with damp sponge.

a. Finishing Levels: Finish panels to levels indicated below and according to ASTM C840, GA-216 or GA-214:
   1) Gypsum Board Surfaces to Receive Paint: GA-214-90 Level Five - 'All joints and interior angles shall have tape embedded in joint compound and three separate coats of joint compound applied over all joints, angles, fastener heads, and accessories. A thin skim coat of joint compound, or a material manufactured especially for this purpose, shall be applied to the entire surface. The surface shall be smooth and free of tool marks and ridges.'
   2) Gypsum Board Surfaces not painted or finished:
      a) GA-214-07e Level 1: 'All joints and interior angles shall have tape set in joint compound. Surface shall be free of excess joint compound. Tool marks and ridges are acceptable.'
   3) Painted, Untextured Gypsum Board Surfaces, Except in Mechanical, Storage, And Utility Areas:
      a) GA-214-07e Level 5: 'All joints and interior angles shall have tape embedded in joint compound and two separate coats of joint compound applied over flat joints and one separate coat of joint compound applied over interior angles. Fastener heads and accessories shall be covered with three separate coats of joint compound. A thin skim coat of joint compound trowel applied, or a material manufactured especially for this purpose and applied in accordance with manufacturer's recommendations, shall be applied to the entire surface. The surface shall be smooth and free of tool marks and ridges. Coat prepared surface with specified primer.'

3.3 FIELD QUALITY CONTROL

A. Non-Conforming Work:
   1. Remove and replace panels that are wet, moisture damaged, and mold damaged.
      a. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
      b. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

3.4 CLEANING

A. Remove from site debris resulting from work of this Section including taping compound spills.

END OF SECTION

SECTION 09 5113

ACOUSTICAL PANEL CEILINGS

PART 1 GENERAL

1.1 SUMMARY

A. Includes But Not Limited To
   1. Furnish and install tile for suspended acoustical ceilings as described in Contract Documents.
   2. Carefully remove, store and re-install existing tile for suspended acoustical ceilings as described in Contract Documents.

B. Related Sections
   1. Section 09 5300 - Acoustical Panel Suspension System'

1.2 SUBMITTALS

A. Product Data
   1. Manufacturer's literature
   2. Color and pattern selections for each room

1.3 DELIVERY, STORAGE, & HANDLING

A. Store materials where protected from moisture and damage.

B. Use no soiled, scratched, or broken material in the Work.

1.4 MAINTENANCE

A. Extra Materials - Provide Owner with one carton of each type of tile for future use.

PART 2 PRODUCTS

2.1 MATERIALS

A. Acoustic Panels
   1. Cast panels, core color to match surface color.
   2. Finish - Use tile from same color run in individual rooms to assure color match.
   3. Rating - none
   4. Thickness - 5/8 inch minimum
   5. Approved Patterns
      a. Match existing patterns and sizes in each room
   6. Approved Manufacturers -
      a. USG
      b. Armstrong

PART 3 EXECUTION

3.1 EXAMINATION

A. Inspect for defects in support which are not acceptable. Report defects to Architect in writing. Do not install ceiling panels until defects in support are corrected.

3.2. INSTALLATION

A. Materials shall be dry and clean at time of application.
B. Axiom trim shall be installed level, plumb and true to the geometry indicated on drawings, and in accordance with the manufacturer's instructions.
C. A pre-installation conference with the architect, installer, and general contractor is required.

3.3 CLEANING

A. 'Touch-up' minor abraded surfaces.

B. Remove from site all debris connected with work of this Section.

C. Remove and replace discolored tile to match adjacent tile.

D. Remove and replace damaged or out-of-level tile at no additional cost to Owner.

END OF SECTION

SECTION 09 5300

ACOUSTICAL CEILING SUSPENSION ASSEMBLIES

PART 1 GENERAL

1.1 SUMMARY

A. Includes But Not Limited To
   1. Furnish and install acoustical suspension system as described in Contract Documents to receive acoustical ceiling panels.
   2. Carefully remove, store, and re-install acoustical suspension system, that is compatible with the existing system, as described in Contract Documents to receive acoustical ceiling panels.

B. Related Sections
   1. Division 25 – HVAC equipment and fixtures in ceiling
   2. Division 26 - Light fixtures in ceilings

1.2 REFERENCES

A. American Society For Testing And Materials
   1. ASTM C 635-95, 'Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings'
   2. ASTM C 636-96, 'Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels'

1.3 QUALITY ASSURANCE

A. Regulatory Requirements - Meet seismic bracing requirements of current locally adopted building code, or equivalent governing standard for Project site.

1.4 SUBMITTALS

A. Product Data
   1. Manufacturer's literature
   2. Color and style for each room

PART 2 PRODUCTS

2.1 COMPONENTS

A. Systems shall meet requirements of ASTM C 635, Heavy Duty, and ESR -1308.

B. Exposed surfaces shall be finished with factory-applied white baked enamel.

C. Design Standard System:
   1. Donn 15/16" DX/DXL
   2. Match suspension system size and style in each room.

E. Wall Molding – BERC2 or equivalent. 2-inch wall angle is acceptable in rooms where that application exists.

F. Hanger Wire - 12 gauge cold-rolled electro-galvanized steel.

2.2 APPROVED MANUFACTURERS

A. USG
B. Armstrong

PART 3 EXECUTION

3.1 INSTALLATION

A. Work shall be in accordance with Manufacturer's recommendations insofar as they are concerned with Contract Documents. Installation shall meet requirements of ASTM C 636.

B. Lay out suspension system symmetrically about center lines of room unless shown otherwise by Drawings. Lay out system so use of tiles less than 1/2 size is minimized.

C. Maintain suspension system in true plane with straight, even joints.

D. Suspension system joints shall be straight and in alignment, and exposed surface flush and level. Wherever system abuts walls, columns, and other vertical surfaces, furnish and install appropriate molding.

E. Locate light fixtures, speakers, and mechanical diffusers and grilles symmetrically in room insofar as possible (unless shown otherwise). Locate fixtures, speakers, diffusers, and grilles within suspension grid spaces and centered at least one direction within grid.

F. Pay particular attention to required hanger wire placement and fixture protection. Individual component deflection not to exceed 1/360 of span.

G. When splicing into existing suspension system, remove all cut lengths of main runners and cross tees, so that all pieces are full (except as required to butt against walls). Existing lengths may be reused if in good clean condition.

H. A pre-installation meeting with the installer, architect, and general contractor is required.

END OF SECTION

SECTION 09 9123

INTERIOR PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENT.

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

B. Clean, repair, and repaint all surfaces damaged by demolition or construction.

1.2 SUMMARY

A. Section includes surface preparation and the application of paint systems on the following interior substrates:
   1. Steel.
   2. Gypsum board.
   3. Concrete Masonry Units

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include preparation requirements and application instructions.

B. Sustainable Design Submittals:

   1. Product Data for Credit EQ 4.2: For paints and coatings, including printed statement of VOC content.
   2. Laboratory Test Reports: For paints and coatings, indicating compliance with requirements for low-emitting materials.

C. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.

   1. Submit Samples on rigid backing, 8 inches square.
   2. Label each coat of each Sample.
   3. Label each Sample for location and application area.

D. Product List: For each product indicated, include the following:

   1. Cross-reference to paint system and locations of application areas. Use same designations indicated on Drawings and in schedules.
   2. VOC content.

1.4 CLOSEOUT SUBMITTALS

A. Coating Maintenance Manual: Provide coating maintenance manual including area summary with finish schedule, area detail designating location where each product/color/finish was used, product data pages, material safety data sheets, care and cleaning instructions, touch-up procedures, and color samples of each color and finish used.

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. Paint: 5 percent, but not less than 1 gallon of each material and color applied.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Handling: Deliver products to Project site in an undamaged condition in manufacturer's original sealed containers, complete with labels and instructions for handling, storing, unpacking, protecting, and installing. Packaging shall bear the manufacturer’s label with the following information:

1. Product name and type (description).
2. Batch date.
3. Color number.
4. VOC content.
5. Environmental handling requirements.
6. Surface preparation requirements.
7. Application instructions.

B. 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.

1.7 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 less than 5 deg F above the dew point; or to damp or wet surfaces.

C. Lead Paint: It is not expected that lead paint will be encountered in the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Sherwin-Williams Company products indicated or comparable product from one of the following:

1. Benjamin Moore.

2. PPG.

3. Sherwin-Williams.

B. Comparable Products: Comparable products of approved manufacturers will be considered in accordance with Section 016000 "Product Requirements," and the following:

1. Products are approved by manufacturer in writing for application specified.

2. Products meet performance and physical characteristics of basis of design product including published ratio of solids by volume, plus or minus two percent.

C. Source Limitations: Obtain paint materials from single source from single listed manufacturer.

1. Manufacturer's designations listed on a separate color schedule are for color reference only and do not indicate prior approval.

2.2 PAINT, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint 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. For each coat in a paint system, provide products recommended in writing by manufacturers of topcoat for use in paint system and on substrate indicated.

B. VOC Content: Utah Administrative Code R307-361 Products shall comply with VOC limits of authorities having jurisdiction and, for interior and exterior paints and coatings applied at Project site, the following VOC limits, exclusive of colorants added to a tint base, when calculated according to 40 CFR 59, Subpart D (EPA Method 24)].

1. Flat Paints and Coatings: 50 g/L.
2. Nonflat Paints and Coatings: 100 g/L.
3. Dry-Fog Coatings: 150 g/L.
4. Primers, Sealers, and Undercoaters: 100 g/L.
5. Industrial maintenance Coatings Applied to Ferrous Metals: 250 g/L.
6. Zinc-Rich Industrial Maintenance Primers: 340 g/L.
7. Pretreatment Wash Primers: 420 g/L.
8. Floor Coatings Foot Traffic: 100 g/L.
9. Floor Coatings High Performance: 250 g/L.
10. Shellacs, Clear: 730 g/L.
11. Shellacs, Pigmented: 550 g/L.
12. Wood Coatings: 275 g/L

C. Colors: As selected by Architect from manufacturer's full range.

1. This project includes a side variety of color including deep tones and multiple colors in individual rooms. See architectural drawings for the full extent of colors.

2.3 SOURCE QUALITY CONTRO

A. Testing of Paint Materials: Owner reserves the right to invoke the following procedure:

1. Owner will engage the services of a qualified testing agency to sample paint materials. Contractor will be notified in advance and may be present when samples are taken. If paint materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
2. Testing agency will perform tests for compliance with product requirements.
3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying paint materials from Project site, pay for testing, and repaint surfaces

painted with rejected materials. Contractor will be required to remove rejected materials from previously painted surfaces if, on repainting with complying materials, the two paints are incompatible.

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. Verify suitability of substrates, including surface conditions and compatibility with existing finishes and primers. Where acceptability of substrate conditions is in question, apply samples and perform in-situ testing to verify compatibility, adhesion, and film integrity of new paint application.

1. Report, in writing, conditions that may affect application, appearance, or performance of paint.

B. Substrate Conditions:

1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   a. Wood: 15 percent.
   b. Gypsum Board: 12 percent.

2. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.

C. Proceed with coating application only after unsatisfactory conditions have been corrected; application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates 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.

1. Concrete Floors: Remove oil, dust, grease, dirt, and other foreign materials. Comply with SSPC-SP-13/NACE 6 or ICRI 03732.

E. Masonry Substrates: Remove efflorescence and chalk. Do not paint surfaces if moisture content or alkalinity of surfaces or mortar joints exceed that permitted in manufacturer's written instructions.

F. Steel Substrates: Remove rust, loose mill scale, and shop primer, if any. Clean using methods recommended in writing by paint manufacturer:

1. SSPC-SP 2, "Hand Tool Cleaning."
2. SSPC-SP 3, "Power Tool Cleaning."
3. SSPC-SP 7/NACE No. 4, "Brush-off Blast Cleaning."
4. SSPC-SP 11, "Power Tool Cleaning to Bare Metal."

G. Shop-Primed Steel Substrates: Clean field welds, bolted connections, and abraded areas of shop paint, and 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 sheet metal fabricated from coil stock 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, and apply coat of knot sealer before applying primer.
2. Sand surfaces that will be exposed to view, and dust off.
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.

3.3 APPLICATION

A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI 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 painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.

B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Tint undercoats to match color of topcoat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. 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.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed in equipment rooms:

a. Equipment, including panelboards and switch gear.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Tanks that do not have factory-applied final finishes.
h. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
i. Mechanical grilles and diffusers.

2. Paint the following work where exposed in occupied spaces:

a. Equipment, including panelboards.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
h. Other items as directed by Architect.
i. Mechanical grilles and diffusers.

3. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

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. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

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

A. Metal Substrates (Aluminum, Steel, Galvanized Steel):

1. Waterbased/Alkyd Urethane System:

a. Prime Coat: S-W Pro Industrial Pro-Cryl Universal Primer, B66-310 Series, at 5.0 to 10.0 mils wet, 2.0 to 4.0 mils dry.
b. Intermediate Coat: Water-based acrylic-alkyd, interior, matching topcoat.
c. Topcoat: Water-based alkyd-urethane, semi-gloss, interior: S-W Pro Industrial Waterbased Alkyd Urethane Semi-Gloss, B53-1150 Series, at 4.0 mils wet, 1.4 mils dry, per coat.

B. Wood Substrates, Stain and Clear Finish:

1. Water Reducible Polyurethane System:

a. First Coat: S-W WoodClassics Oil Stain, <250 VOC A49 Series.
b. Topcoat: S-W MinWax WaterBased Polyurethane Satin <275 VOC.

C. Gypsum Board Substrates:

1. Latex System:
a. Topcoat: Latex, interior, eggshell: S-W ProMar 200 Zero VOC Latex Eg-Shel, B20-2600 Series, at 4.0 mils wet, 1.7 mils dry, per coat.

2. Water-Based Light Industrial Coating System:

a. Prime Coat: Primer sealer, latex, interior: S-W ProMar 200 Zero VOC Latex Primer, B28W2600, at 4.0 mils wet, 1.0 mils dry.
b. Intermediate Coat: Light industrial coating, interior, water based, matching topcoat.
c. Topcoat: Light industrial coating, interior, water based, semi-gloss: S-W Pro Industrial Pre-Catalyzed Waterbased Epoxy, K46-151 Series, at 4.0 mils wet, 1.5 mils dry, per coat.

END OF SECTION

SECTION 115313 – LABORATORY FUME HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Bench-top High-Performance Laboratory Fume Hoods.
2. Service fixtures (ie. water, gas, etc.) and electrical service fittings in fume hoods.
3. Piping and wiring within service fittings, light fixtures, switches, and other electrical devices.
4. Fume hood base support.
5. Work Surfaces within fume hoods.
6. Laboratory sinks and cup sinks in fume hoods.
7. Filler panels and ceiling enclosures for fume hoods.

1.2 SCOPE AND CLASSIFICATION

A. This specification covers the requirements for bench mounted laboratory fume hoods for use with remote exhaust blower systems.

B. Bench-mounted laboratory fume hoods of size listed on the equipment schedule.

C. This specification sets the intent for quality, performance and appearance.

1.3 REFERENCES

A. The laboratory hoods must conform to the following regulations and standards.
1. SEFA 1-2010, Scientific Equipment and Furniture Association , Recommended Practices for Laboratory Fume Hoods
2. SEFA 8-2010, Recommended Practices for Laboratory Grade Metal Casework, 8.0 Cabinet Surface Finish Tests
3. NFPA 45-2011, National Fire Protection Association, Fire Protection for Laboratories Using Chemicals
4. ASTM E84-09C, ANSI 2.5, NFPA 255, UL 723, UBC 8-1 (42-1), Standard Test method for Surface Burning Characteristics of Building Materials
5. ASHRAE 110-2016, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Method of Testing Performance of Laboratory Fume Hoods
6. ANSI/AIHA Z9.5-2011, American Industrial Hygiene Association, Laboratory Ventilation
7. OSHA, Federal Register 29 CFR Part 1910, Occupational Safety & Health Administration, U.S. Department of Labor, Occupational exposures to hazardous chemicals in laboratories.

B. The laboratory fume hoods must carry the ETL listed mark for the following.
1. UL 61010-1 (formerly 3101-1), Underwriters Laboratories Inc., Electrical Equipment for Laboratory Use
2. UL 1805, Underwriters Laboratories Inc., Standard for Laboratory Hoods and Cabinets

1.4 PERFORMANCE REQUIREMENTS

A. General Design Requirements (See Part 2 for details)
1. Fume hoods shall function as ventilated, enclosed workspaces, designed to capture, contain and exhaust fumes, vapors and particulate matter produced or generated within the enclosure.
2. Fume hood shall be factory designed to function as a variable air volume fume hood.
3. Structure and Materials of construction
   a. Hoods are of double-wall construction
   b. Powder-coated, cold rolled steel exterior
   c. Galvanized steel support members
   d. Sheet molded composite panel internal liner
4. Baffles
   a. Baffle slot pattern designed to optimize face velocity profile.
   b. Moving or adjustable baffles are not acceptable
5. Sash
   a. Maximum opening is 28".
   b. Unobstructed viewing height is 37.5".
   c. Hood incorporates a perforated sash handle to bleed air into the hood chamber directing fume concentrations away from the user's breathing zone.
6. Airfoil:
   a. Hoods are provided with an air foil across the bottom of the sash area to allow airflow into the hood regardless of user's position.
7. Access for maintenance is from both the front, interior, and exterior sides of the hood.
8. Services:
   a. Furnishing and delivering all service outlets, accessory fittings, electrical receptacles and switches, as listed in these specifications, equipment schedules or as shown on drawings.
   b. Plumbing fittings mounted on the fume hood superstructures shall be pre-plumbed per section 2.03.
   c. All hood mounted service fixtures shall be preplumbed to a single point connection at top of hood.
   d. All electrical services are pre-wired to a single point internal junction box at the top right of the hood.
9. Hoods without service fixtures pass through a 33” opening without disassembly.

B. Containment
1. Evaluation of manufacturer’s standard product shall take place in manufacturer’s test facility meeting the following criteria.
   a. Lab to be located at manufacturer’s place of business for the testing of bench-mounted laboratory hoods in accordance with ASHRAE Standard 110.
   b. The facility's ventilation system shall have adequate heating and air conditioning so that room air temperatures can be maintained within the desired ranges.
   c. One hundred percent non-recirculated air to be both carbon and HEPA filtered to ensure removal of contaminants that could interfere with containment testing before entering the lab.
   d. Make-up air to the test room shall be ceiling-supplied through any combination of multiple diffusers to either minimize adverse airflow, or increase it depending on test objectives.
   e. Exhaust volumes shall be computer controlled and measured via AMCA calibrated orifices and flow station at each exhaust trunk.
   f. Room pressurization must be digitally monitored, and variable depending on test objectives.
   g. All equipment must be properly calibrated.

h. Qualified personnel familiar with the laboratory and its operation shall be available to perform the test.
i. Include the following instrumentation and test equipment:
   1) Properly calibrated hot wire thermal anemometer capable of measuring air velocities from 10 to 600 ft/minute; correlate with computer data acquisition format to provide simultaneous readings at all points.
   2) Theatrical smoke generator or other source of high volume smoke.
   3) Smoke tubes or other source of localized smoke.
   4) Leakmeter with traceable calibration, calibrated just before test, to indicated concentration of sulfur hexafluoride.
   5) Tracer gas: Sulfur hexafluoride supplied from a cylinder with two stage regulator.
   6) Adjustable mannequin, 5' 0' to 5'8" in height, with reasonable human proportions, clothed in a smock
   7) Inclined manometer with graduations no greater than 0.2 inch of water.
   8) Ejector system: Tracer gas ejector built to specific ASHRAE-110 requirements.
   9) Critical orifice: Sized to provide tracer gas at four or eight liters per minute at an upstream pressure sufficient to maintain release rate.
   10) Data acquisition software to include HoodPro™ and LabMeasurePro™ from Exposure Control Technologies, Inc.

2. Hood shall be tested to ASHRAE 110 modified test method as detailed below.
3. Fume hood sashes shall be placed in their full open position, at least 28” from the work surface, unless noted otherwise.
4. Ambient Temperature: 68 to 74 degrees F
5. Average Face Velocity: Face velocity average shall be 60 fpm plus or minus 5%.
   a. An imaginary grid is formed comprised of equal 12” by 12” squares, or smaller, across the face opening of the laboratory hood. Airflow velocity readings are taken at the intersections of these grids with calibrated hot wire anemometer over a twenty second period of time. Probes shall communicate readings to a computer data acquisition package, which will provide an average of each reading over the one-minute period and also an overall average upon completion of data acquisition. Face velocity shall be determined by averaging readings at the hood face.
   b. Average face velocity must be achieved without exceeding the CFM noted in part C.
6. Tracer Gas Detection: Hood shall achieve a rating of 4.0AM0.00 maximum average and 4.0AM0.01 maximum spike (unless specifically otherwise noted), wherein:
   a. 4.0 = tracer gas release in liters/minute, AM = as manufactured, 0.01 = tracer gas in parts per million (PPM)
   b. With the ejector body 6" from the rear of the sash plane, the test shall be conducted for each ejector position noted.
      1) Left position with ejector 12" from the left interior wall.
      2) Center position with ejector equidistant from the sidewalls.
      3) Right position with ejector 12" from the right interior wall.
   c. Install mannequin positioned in front of the hood, centered on the ejector.
   d. Detector probes shall be placed 3” in front of the sash plane. The test shall be conducted for each detector probe position and corresponding face velocity.
      1) Detector probe in the region of the nose and mouth of the mannequin. Test with average face velocity of 60 fpm.
      2) With the mannequin height reduced 4”, place detector probe in the chest of the mannequin, and even with the height of the ejector. Test with average face velocity of 60 fpm.
   e. Open tracer gas valve, and collect readings with a computer data acquisition package, which is capable of monitoring and visually recording a minimum of one reading per second for a minimal five minute time period for each position.

f. The single control rating of the fume hood shall be the results of the test position yielding the highest average levels of tracer gas in any of the six mannequin/ejector configurations.
g. With the ejector and mannequin in the center position, detector probe in the region of the nose and mouth of the mannequin, average face velocity of 60 fpm, tracer gas released, and concentration recorded, open and close the sash in a smooth motion. Test to be repeated three times, with peak values of 0.01 PPM or less.
h. With the mannequin removed, the periphery of the hood is traversed by the probe at 1" in front of the hood opening at a rate of 3 inches per second. The hood shall have a maximum perimeter reading of 0.03 PPM or less.

7. Flow Visualization:
   a. Test the operation of the lower air bypass airflow opening and hood periphery by introducing light smoke under the air foil, and around the perimeter of the sash opening. If any smoke that enters the hood reverses directions and escapes from any of these locations, the hood fails this portion of the test and receives no rating.
   b. Introduce smoke along both walls and the hood floor in a line parallel to the hood face and 6 inches (152 mm) back into the hood. Define air movement toward the face of the hood as reverse airflow and define lack of movement as dead air space. All smoke should be carried to the back of the hood and out.
   c. Introduce a large volume of smoke at the work surface in the center of the hood, and 6" inside the plane of the sash. Define air movement toward the face of the hood as reverse airflow and define lack of movement as dead air space. All smoke should be carried to the back of the hood and out.
   d. All data on the above, including instrumentation and equipment, and test conditions shall be provided on a report, including the average face velocities, and a separate graph-type performance curve on all tracer gas tests for all required fume hood widths. Performance test data for a 6' representative hood shall be conducted by an independent testing agency and by a specific individual certified to perform such tests by the National Environmental Balancing Bureau (NEBB).

8. Efficiencies: The fume hood shall maintain constant volumetric rate (+/- 5 CFM) and static pressure losses (+/- 0.01" H2O) across all sash positions, unless the hood has a restricted by-pass for use with a variable air volume (VAV) system.

C.
1. The fume hood shall demonstrate a minimization of the volumetric rate of air (CFM) requirement at any given face velocity. Required CFM to achieve desired face velocity shall not exceed that which is noted in the chart below.
2. The fume hood shall demonstrate a minimization of static pressure loss (inches of H2O) at any given CFM. Static pressure loss at desired face velocity, and corresponding CFM, shall not exceed that which is noted in the chart below.

Face Velocity (fpm) Sash at 28" Open	Airflow Rate (CFM) @ Static Pressure (inches of H2O)					
	3' Hood	4' Hood	5' Hood	6' Hood	7' Hood	8' Hood
100	495, 0.13"	725, 0.27"	955, 0.34"	1180, 0.46"	1410, 0.23"	1640, 0.31"
80	395, 0.08"	580, 0.17"	765, 0.22"	945, 0.29"	1125, 0.15"	1310, 0.20"
60	295, 0.05"	435, 0.10"	575, 0.12"	710, 0.17"	845, 0.08"	985, 0.11"
Face Velocity (fpm) Sash at 18" Open	Airflow Rate (CFM) @ Static Pressure (inches of H2O)					
	3' Hood	4' Hood	5' Hood	6' Hood	7' Hood	8' Hood
100	310, 0.05"	450, 0.11"	595, 0.13"	735, 0.18"	880, 0.09"	1025, 0.12"
80	250, 0.03"	365, 0.07"	480, 0.09"	590, 0.11"	705, 0.06"	820, 0.08"
60	185, 0.02"	270, 0.04"	360, 0.05"	440, 0.07"	525, 0.03"	615, 0.04"

D. Noise Criterion: The hood shall have a Noise Criterion (NC) rating of less than 50; measured 36" in front of the hood with full open sash, at 100 fpm face velocity. NC is a factor of sound pressure level (dB) and frequency.

E. Illumination: Shall be a minimum average of 80 foot-candles inside the work area. Work area is defined as the area inside the lined portion of the fume hood, from the face of baffle to sash plane, from interior left to interior right, and from the work surface to a height of 28 inches.

F. Materials of Construction: Interior and Exterior materials of construction and finishes shall meet the requirements in Part 2 of this specification.

1.5 QUALITY ASSURANCE

A. Fume hoods shall be designed, including comprehensive engineering analysis, by a qualified, licensed Professional Engineer.

B. Manufacturer's Qualifications
1. ISO 9001 Certified manufacturing plant and processes.
2. Ten installations of equal or larger size and requirements. Provide contact at each.
3. Only hood manufacturers who have had fume hoods as a principal product for 30 years are considered.

C. Supply all equipment in accordance with this specification. Offering a product differing in materials, construction, or performance from this specification requires written approval obtained seven days or more before the proposal deadline.

D. The owner/architect reserves the right to reject qualified or alternate proposals and to award based on product value where such action assures the owner greater integrity of product.

E. Manufacturer's warranty against defects in material or workmanship on its fume hoods will be for 1 year from date of substantial completion, and includes replacement of parts (except lamps) and labor.

1.6 SUBMITTALS

A. Action Submittals
1. Laboratory hood specification sheets and product manuals shall be submitted by the hood manufacturer upon request, and include safe and proper operation and maintenance information.
2. Shop Drawings: Include plans, elevations, sections, and details.
   a. Indicate details for anchoring fume hoods to permanent building construction including locations of blocking and other supports.
   b. Indicate locations and types of service fittings together with associated service supply connection required.
   c. Indicate duct connections, electrical connections, and locations of access panels.
   d. Include roughing-in information for mechanical, plumbing, and electrical connections.
   e. Provide face opening, volumetric rates, and static pressure drop data.
3. Submit a document detailing the information supplied on the Hood Safety Practices Label to verify compliance to specifications.

B. Informational Submittals
1. Product Test Reports: Showing compliance with specified performance requirements, including NEBB representative test report as defined previously.
2. Independent validation:
   a. Written verification that the laboratory fume hoods carry the ETL listed mark for the following.
      1) UL 61010-1 (formerly 3101-1), Underwriters Laboratories Inc., Electrical Equipment for Laboratory Use
      2) CAN/CSA C22.2 No. 61010-1, Canadian Standards Association, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use
      3) UL 1805, Underwriters Laboratories Inc., Standard for Laboratory Hoods and Cabinets
   b. Written verification that 230 volt model fume hoods carry the CE conformity marking as required by the Council of European Communities.
   c. Written verification from an outside testing agency confirming coating compliance to SEFA 8-2010, Recommended Practices for Laboratory Grade Metal Casework, 8.0 Cabinet Surface Finish Tests
3. Documentation of ISO 9001 Certified manufacturing plant and processes.
4. List of five installations (of equal or larger size and requirements) is available upon request. Provide contact at each.
5. Declaration of Made in America. Owner reserves the right to evaluate Made in America claims for compliance with the Bureau of Consumer Protection.

C. Material Submittals
   1. Samples for Verification: of the hood exterior wall material, interior liner and baffle material, epoxy work surface material, and color selection chips are available from the hood manufacturer upon request.

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Schedule delivery of equipment so that spaces are sufficiently complete that equipment can be installed immediately following delivery.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install fume hoods until building is enclosed, wet work and utility roughing-in are complete, and HVAC system is operating and maintaining temperature and relative humidity at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Labconco Protector XL
B. Other acceptable manufacturers:
   1. Kewanee
   2. Mott
   3. BEDCO

2.2 MATERIALS

A. Hood Interior Liner and Baffle
   1. Liner material must comply with UL 1805, and be listed within NRTL test report as proof of compliance.
   2. General Material Properties
      a. Nonflammable, corrosion and chemical-resistant
      b. Sheet molded homogenous polyester panels
      c. Minimum thickness is 3/16"
      d. Smooth, white finish
   3. Mechanical Properties
      a. Tensile Strength: 7,500 PSI (51.7 Mpa)
      b. Tensile Modulus: 1.7 x 10^6 PSI (11,700 Mpa)
      c. Flexural Strength: 21,000 PSI (145 Mpa)
      d. Flexural Strength at 130 degrees C: 12,900 PSI (89 Mpa)
      e. Compressive Strength: 32,500 PSI (224 Mpa)
      f. IZOD Impact Strength (Notched): 8.4 Ft Lb/in (4.5 J/cm)
   4. Flame and Smoke Characteristics
      a. Flame retardant, self-extinguishing, with a flame spread rating of 25 or less in accordance with ASTM-E84
      b. Oxygen Index: 35%

c. Smoke Density: 115

5. Physical Properties
   a. Water Absorption: 0.4%
   b. Specific Gravity: 4.81
   c. Coefficient of Thermal Expansion: 2 In/in/ degree C x 10^-5
   d. Thermal Conductivity: 1.9 BTU/Hr/Ft^2/In/degree F
6. Chemical Resistance
   a. Splash and Spill Resistance:
      1) Suspend sample panel in a vertical plane
      2) Apply five drops of each reagent listed with an eyedropper
      3) Apply liquid reagents at top of panel and allow to flow down full panel height
   b. Fume Resistance:
      1) Place 25 milliliters of reagent into 100 milliliters beakers and position panel over beaker tops in the proper sequence. Ensure beaker pouring lip permits air to enter the interior atmosphere.
      2) After 24 hours remove panel, flush with water, clean with detergent, rinse, wipe dry and evaluate
   c. Evaluation ratings: Change in surface finish and function shall be described by the following numerical ratings
      1) No Effect: No change in color or gloss
      2) Excellent: Slight detectable change in color or gloss, but no change to the function or life of the work surface material
      3) Good: Clearly discernible change in color or gloss, but no significant impairment of function or life
      4) Fair: Objectionable change in appearance due to surface discoloration or etch, possibly resulting in deterioration of function over an extended period
      5) Failure: Pitting, cratering or erosion of work surface material; obvious and significant deterioration
   d. Required minimum results for each reagent (Reagent: Fume Resistance Rating, Splash and Spill Resistance Rating)

1)	Hydrochloric Acid (37%):	2,1
2)	Sulfuric Acid (33%):	2,1
3)	Sulfuric Acid (77%):	1,1
4)	Sulfuric Acid (96%):	1,2
5)	Formic Acid (90%):	2,1
6)	Nitric Acid (20%):	2,2
7)	Nitric Acid (30%):	1,2
8)	Nitric Acid (70%):	3,2
9)	Hydrofluoric Acid (48%):	2,2
10)	Phosphoric Acid (85%):	1,1
11)	Chromic Acid (60%):	1,4
12)	Acetic Acid (98%):	1,1
13)	Ammonium Hydroxide (20%):	1,1
14)	Sodium Hydroxide (10%):	1,1
15)	Sodium Hydroxide (20%):	1,3
16)	Sodium Hydroxide (40%):	1,3
17)	Sodium Hydroxide Flake:	1,-
18)	Sodium Sulfide:	1,1
19)	Zinc Chloride:	2,1
20)	Tincture of Iodine:	3,3
21)	Silver Nitrate:	2,1
22)	Methyl Alcohol:	1,1
23)	Ethyl Alcohol:	1,1
24)	Butyl Alcohol:	1,1
25)	Benzene:	1,1

26)	Xylene:	1,1
27)	Toluene:	1,1
28)	Gasoline:	1,1
29)	Dichloro Acetic Acid:	2,2
30)	Dimethyl Formanide:	2,2
31)	Ethyl Acetate:	1,1
32)	Amyl Acetate:	1,1
33)	Acetone:	1,1
34)	Chloroform:	1,1
35)	Carbon Tetrachloride:	1,1
36)	Phenol:	2,2
37)	Cresol:	1,1
38)	Formaldehyde:	1,1
39)	Trichloroethylene:	1,1
40)	Ethyl Ether:	1,1
41)	Furfural:	1,3
42)	Methylene Chloride:	1,1
43)	Mono Chloro Benzene:	1,1
44)	Dioxane:	1,1
45)	Methyl Ethyl Ketone:	1,1
46)	Acid Dichromate:	1,2
47)	Hydrogen Peroxide:	1,1
48)	Napthalene:	1,1

B. Sheet Steel
1. Side panels and access panels 20-gauge (or heavier) sheet steel.
2. Hood corner posts are 16-gauge sheet steel.
3. Ceiling enclosure panels are 18 gauge sheet steel.
4. Cold-rolled, commercial steel (CS) sheet, complying with ASTM A 1008/A 1008M.

C. Chemical Resistant Finish
1. General: Prepare, treat, and finish welded assemblies after welding. Prepare, treat, and finish components that are to be assembled with mechanical fasteners before assembling.
2. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8. Third party validation required.
3. Powder-coat process required. Paint processes that release Volatile Organic Compounds (VOC) are not acceptable
4. Color for Fume Hood Finish:
   a. As selected by owner from Manufacturer's full range

D. Safety Glass
1. Tempered
   a. Clarity and temper test to be as specified in latest edition of Glass Tempering Association, *Engineering Standards Manual*, Section 8.1.
   b. Surface and interior visible quality to be as specified per ASTM C 1036, *Standard Specification for Flat Glass*, Table 4, Quality level Q3.

2.3 CONSTRUCTION

A. Superstructure:
1. Self-supporting, rigid structural assembly, to support inner wall consisting of fume hood liner and outer wall of sheet metal exterior.
2. Fabricated from galvanized steel.
3. Space shall accommodate fume hood wiring and plumbing components for service fixtures.

4. Access to fixture valves concealed in wall provided by exterior removable access panels, gasket access panels on the inside liner walls, or through removable access panels on the front posts.

B. Exterior
1. Fabricate from steel sheet with component parts screwed together.
2. Apply chemical-resistant finish to interior and exterior surfaces of component parts before assembly.
3. Interchangeable side panels shall lift off without the use of tools to allow access to plumbing lines, service fittings, electrical wiring, counterbalance sash weights, and light fixtures. Exposed fasteners or hardware, and Velcro type fasteners, are not acceptable.
4. Corner posts
   a. Pre-punched and plugged to accommodate up to 4 service fixtures per side
   b. All services are accessible from the front of the hood.
   c. Aerodynamic shape
   d. Accommodate two electrical duplexes per side.
   e. Right hand corner post includes electrical switches and pre-cut for Airflow monitor installation.
   f. Un-used penetrations shall be plugged.
5. Top and sides of face opening to provide an aerodynamic shape to ensure smooth, even flow of air into fume hood.
6. Panel above header shall be removable without the use of tools to allow access to mechanical connection, electrical wiring, counterbalance sash weights, and light fixtures. Exposed fasteners or hardware, and “hook-and-loop” type fasteners, are not acceptable.

C. Hood Liner
1. Adhere interior liner components to superstructure.
2. Stainless steel fasteners shall be used on the interior ceiling for structural integrity.
3. Fasteners exposed to chemical environment are not acceptable.
4. Punch fume hood lining side panels to receive four service fittings, for use with remote controls, per side. Provide removable plug buttons for holes not used for indicated fittings.
5. Each side wall shall include an oval interior access panel to provide access to the side wall of the fume hood for plumbing service access. Access panel material shall be that of the liner, and gasketed to form a vapor proof seal.

D. Hood Baffle
1. Baffle system shall be designed to optimize the face velocity profile, and to capture a wide range of gaseous densities without adjustment or moving components.
2. Shall provide a continuous horizontal slot at the work surface. Baffle panels shall have multiple horizontal slots, with a chamfered entry. Slot pattern shall be proven to optimize face velocity profile.
3. The baffle system shall be constructed with the same material as the fume hood liner.
4. The baffles shall be removable for cleaning. The primary baffles shall be three pieces to allow removal without the use of tools.
5. Exposed components to be non-metallic. Metal components exposed to chemical environment are not acceptable.
6. Moving parts or adjustment of any kind is not acceptable.

E. Exhaust Connection
1. 316 stainless steel with Chemical-Resistant Finish
2. 12.81" ID to accommodate any 12” nominal duct without the need for a transition adapter. 3, 4, 5, and 6-foot hoods have one exhaust connection, 7 and 8-foot hoods have two exhaust connections. Additional components required to accommodate 12” nominal mechanical system are not acceptable.

3. Ducting shall go inside the duct collar to ensure condensate travels into the hood and evaporates. Duct collars that allow duct connection over the collar are not acceptable.

F. Airfoil
1. Cold Rolled Steel with Chemical-Resistant Finish.
2. Airfoil shall have an aerodynamic radius to sweep the air into the hood with minimal turbulence. Airfoil directs airflow across work top to remove heavier-than-air gases.
3. Must have 5 rows of perforations to allow the air to bypass underneath and through the foil and sweep across the work surface to prevent any back flow of fumes escaping from the front of the hood opening. This airflow continues even if blocked by the presence of the operator.
4. Foil must extend back under the sash to prevent closure of the lower by-pass opening when the sash is in the fully closed position, directly on top of the airfoil.

G. Sash Assembly
1. Glass: Fully tempered safety glass with unobstructed, side-to-side view of fume hood interior and service fixture connections.
2. Dimensions: The full sash opening height is 28", the total unobstructed viewing height is 37.5" measured from the work surface.
3. Sash Tracks: Steel with Chemical Resistant Finish. Shall include bump stops for opening and closing.
4. Sash Handle: extruded aluminum with Chemcial Resistant Finish. Sash handle includes a perforated air passage directly atop the handle to bleed air into the hood chamber and direct chemical fumes away from the user's breathing zone. The handle is ergonomic in design and is easy to grasp when operating
5. Sash guides: Corrosion resistant extruded poly-vinyl chloride.
6. Sash System
   a. Vertical Sash (Cable and Pulley)
      1) Hoods have a single vertical sash counterbalanced by a single weight.
      2) Sash and weight to be connected via aircraft cable meeting MIL-W-83420 Military Specification.
      3) Rear pulleys shall be connected via timing shaft to prevent sash tilting and permit one finger operation at any point along full width sash handle. Maximum 7 pounds pull required to raise or lower sash throughout its full length of travel.
      4) Design system to hold sash at any position without creep and to prevent sash drop in the event of cable failure.
      5) Include a defeatable, and automatically resetting sash stop positioned for an 18” sash height.

H. Electrical Components
1. Lighting
   a. Provide UL Listed, high-efficiency, LED lighting systems.
   b. Vapor-Proof: all electrical components shall be outside of the contaminated air space. Lighting shall be located behind a laminated safety glass shield, sealed to the top of the hood liner.
   c. The light assemblies shall be serviceable from outside the fume hood cavity, without the use of tools.
   d. Light switch to be included on the lower right corner post, at heights compliant with the Americans with Disabilities Act (ADA).
2. Blower Switch
   a. Hoods shall be provided without a blower switch, as they will share a single mechanical system with other hoods.
3. Electrical Receptacles

a. The hoods shall accommodate up to four (two per corner post) electrical receptacles as indicted in schedule or drawings. Options to include:
   1) 115 volt, 60 Hz, three-wire polarized and grounded electrical duplex, with Ground Fault Circuit Interruption (GFCI)
   2) 230volt, 60 Hz, three-wire polarized and grounded electrical duplex
b. Receptacles shall be individually wired to field wiring box, and each rated at 20 Amperes.
c. Cover plates shall be acid resistant thermoplastic.

4. Wiring
   a. Every electrical component shall be individually wired to a single point internal field wiring box (including individual duplexes/receptacles).
   b. Field wiring box to be 7” x 4” x 2.5”, grounded, and have (12) 7/8” diameter knock out penetrations.
   c. Final wiring and circuit dedication is to be by others.
   d. Each receptacle circuit shall accommodate being wired to a dedicated building circuit rated at 20A, or the receptacles ganged together on a building circuit with the total load not exceeding 20 Amperes.
5. Fume hood to have third party validation of compliance to UL 1805 and UL 61010-1 by a Nationally Recognized Testing Laboratory (NRTL)

I. By-Pass Opening
1. Shall offer a significant restriction to the by-pass opening to allow the use of a VAV mechanical system.

J. Hood Safety Practices Label: Corrosion resistant plate attached to the left corner post of the fume hood with the following Hood Safety Practices:
1. For use with substances that produce hazardous levels of airborne chemicals: gas, fumes, vapors, dust
2. Do not put your head in the hood.
3. Minimize drafts and sudden movements in front of the hood.
4. Work a minimum of six inches inside the hood.
5. Elevate equipment above the work surface.
6. Keep sill and baffle unobstructed.
7. Do not use the hood for storage.
8. Adjust the sash to smallest opening possible when in use.
9. Close sash when unattended.
10. Do not remove any of the hood components.
11. Do not place flammable solvents near heat, flame or sparks.
12. Do not evaporate large amounts of flammable liquids.
13. Wipe up spills immediately.
14. Routinely validate airflow.
15. If the ventilation system malfunctions, or airflow alarm indicates unsafe condition, close sash and discontinue hood operation immediately-call for help.
16. Do not use with Biohazards or Perchloric Acid

K. Fume Hood Accessories
1. Service Fixtures: Color-coded hose nozzle outlets and valves mounted inside the fume hood and controlled from the exterior with color-coded index handles
   a. The hoods are equipped without service fixtures or will be provided with a total of up to 8 service fixtures as indicated in schedule.
   b. Hose connectors located inside the fume hood cavity are chemically-resistant, glass-filled polypropylene with 6 serrations.
   c. Service lines shall be factory installed from valve to outlet
      1) Copper tubing unless otherwise noted
      2) Brass service lines for gas

3) Stainless steel service lines for Deionized Water
4) Connections shall be made with quick-connect compression fittings on the inlet and outlet of the valve body, soldered and brazed connections not easily disassembled are not acceptable.

d. Valves
1) Extruded brass valve and rotating seat, TFE-coated silicone bronze stem and TFE packing.
2) Fixture handles are plastic and color coded as well as labeled for the designated type of service.
3) Fixtures are rated at maximum pressure of 200 psi.
4) Coefficient of flow for the valve, Cv=0.43.
5) Valves are front loaded, located on the fume hood corner post for remote use, and include:
a) Hot and cold tap water
b) Natural gas
c) Air
d) Vacuum
e) Nitrogen
f) Argon
g) Oxygen (include oxygen compatible lubricant)
h) Deionized/Distilled water (Nickel plated and stainless steel components)

2. Tissue Screen: Provide epoxy-coated, stainless-steel screen at bottom baffle opening to prevent paper from being drawn into the exhaust plenum behind baffles.
3. Rear Finish Panel: Shall be the same materials and coating as the hood exterior.
4. Ceiling Enclosure Panels:
a. Provide filler panels matching fume hood exterior to enclose space above fume hoods at front and sides of fume hoods and extending from tops of fume hoods to ceiling.
b. Exposed fasteners are not acceptable.
5. Face Velocity Monitor/Alarm
a. Variable Air Volume (VAV) Prepared
1) Fume hoods shall come factory prepared with the proper cutouts and brackets to field mount specified VAV controller.

L. Work Surface
1. 1.25” thick, molded from solid modified epoxy resin, with smooth, non-specular, black finish.
2. One inch radius front edge for optimal fume hood performance.
3. 3/8” dished area to match the fume hood interior work space and form a water tight pan for spill containment.
4. Include a 2.5” diameter hole on each side for service pass-through and piping. Hole to be covered by hood superstructure upon installation.
5. Include two 1.5” diameter penetrations to accommodate base cabinet venting. Holes to be located outside of dished area and under the fume hood baffles. Include plugs.
6. Physical Properties:
a. Flexural Strength: Not less than 10,000 psi (70 MPa).
b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
c. Hardness (Rockwell M): Not less than 100.
d. Water Absorption (24 Hours): Not more than 0.02 percent.
e. Heat Distortion Point: Not less than 260 deg F (127 deg C).
f. Flame-Spread Index: 25 or less per ASTM E 84.
7. Cupsink
a. 3 x 6” dimension, polypropylene construction
b. Provide with strainers and tailpieces, NPS 1-1/2 (DN 40)
c. To sit flush with dished area of work surface

M. Supporting Base Cabinets
1. Base cabinets shall be in depths of 22", widths, quantities, and types called out in the equipment schedule, and meet the requirements of this specification.
2. Construction requirements for all cabinets
   a. Exterior construction is 18 gauge (or heavier) cold rolled sheet steel with Chemical Resistant Finish.
   b. Hinges are 10 gauge (or heavier) plate with self-clinching pilot pin. Knuckle, bullet, or piano type hinges are not accepted.
   c. The rear panel will feature a 12" x 8" removable plumbing access panel.
   d. Units 24" wide or less have only one door.
   e. Each cabinet includes four leveling feet.
   f. Capable of supporting up to 800 pounds.
   g. A filler panel is required to increases the cabinet depth to work surface depth.
3. Acid Storage (Label as “Corrosive”)
   a. Overall exterior dimensions:
      1) 48" 48" w x 22" d x 35.5"-36.75"
      2) 36" 36" w x 22" d x 35.5"-36.75"
      3) 30" 30" w x 22" d x 35.5"-36.75"
      4) 24" 24" w x 22" d x 35.5"-36.75" h or 31.5"-32.75" for ADA cabinet
      5) 18" 18" w x 22" d x 35.5"-36.75" h or 31.5"-32.75" for ADA cabinet
   b. Completely lined with a polyethylene corrosion resistant liner. The liner is 3/16" thick, with a vacuum formed PVC liner pan at the bottom to contain spills. Each door has a 3/16" sheet polyethylene liner.
   c. The cabinet is labeled: “CORROSIVE”
   d. Flush pull handles are ABS, low gloss black.
   e. Each cabinet is vented into the fume hood with a 1-1/2" vent pipe. It should provide a positive airflow directly into the fume hood exhaust system.
   f. Acid cabinets with louvers are not acceptable
4. Solvent Storage (Label as “Flammable”)
   a. Solvent storage cabinets are specifically designed for the storage of flammable and combustible liquids.
   b. Solvent Storage Cabinet must be compliant with NFPA 30 “Flammability and Combustible Liquids Code.”
   c. Cabinets 30" wide and greater shall be tested and approved by Factory Mutual to meet Factory Mutual Approval Standard 6050.
   d. The bottoms, top, sides, and doors are fabricated of 18 gauge steel and are all double panel construction with a 1-1/2" air space between panels.
   e. All joints are welded or screwed to provide a rigid enclosure. A 2" deep liquid tight pan that covers the entire bottom of the cabinet is furnished to contain liquid leaks and spills.
   f. A full-depth, 18 gauge steel, adjustable shelf is also provided. Shelves are sealed leak tight.
   g. Two diametrically opposed flame arrestor vents with spark screens are provided in the back of the cabinet, as well as a grounding screw.
   h. The cabinet has an interior finish same as the exterior.
   i. The cabinet is labeled: "FLAMMABLE - KEEP FIRE AWAY".
   j. The door shall have a three point latching device.
   k. Door handles include a key lock. Solvent storage handles are locking lever handles with bright chrome finish.
   l. Self-closing/self-latching models shall be provided with a fusible-link feature to ensure the doors will close if the temperature outside the cabinet exceeds 165 degrees Fahrenheit. The doors are synchronized so that both doors will fully close.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify equipment rough-in before proceeding with work.

B. Coordinate with other trades for the proper and correct installation of plumbing and electrical rough-in and for rough opening dimensions required for the installation of the hood.

3.2 INSTALLATION

A. Install according to manufacturer's instructions.

B. Seismic Bracing: The fume hood and base cabinet shall be seismically braced in accordance with the IBC and ASCE 7 standards for Bracing of non-structural components as follows:
   1. The fume hood shall be connected to the countertop by:
      a. Option 1: Using (2) #12 screws or (3) #8 screws at each corner, of
      b. Option 2: Using (1) Simpson Add ‘L’ bracket in each corner of fume hood with (4) #8 screws in each leg of bracket.
   2. The countertop shall be attached to the cabinet base with (3) #8 screws in each corner of this countertop.
   3. The cabinet base shall be attached to the floor with one Simpson A33 bracket installed on the foot of each corner of the cabinet base supporting the fume hood. Anchor brackets to unit with (4) #12 screws. Anchor brackets to the floor with (4) 3/16 x 1” embedment Hilti Kwik Con II or (1) Powers Mini Dropln 3/4” Embed with 3/8” threaded rod.

C. Install according to standards required by authority having jurisdiction.

D. Install equipment plumb, square and straight with no distortion and securely anchor as required.

E. Sequence installations to ensure utility connections are achieved in an orderly and expeditious manner.

F. Touch up minor damaged surfaces caused by installation. Replace damaged components as directed by Architect.

3.3 ADJUSTING

A. Adjust operating equipment, with exception of air moving equipment, to efficient operation for its intended use, and as required by the manufacturer.

3.4 CLEANING

A. Clean equipment, casework, countertops and all other surfaces as recommended by the manufacturer, rendering all work in a new and unused appearance.

B. Clean adjacent construction and surfaces that may have been soiled in the course of installation of work in this section.

3.5 PROTECTION OF FINISHED WORK

A. Provide all necessary protective measures to prevent exposure of equipment and surfaces from exposure to other construction activity.

B. Advise contractor of procedures and precautions for protection of material and installed equipment and casework from damage by work of other trades.

3.6 DEMONSTRATION

A. Provide systems demonstration and demonstrate all equipment operations and functions.

END OF SECTION 115313

TABLE OF CONTENTS

DIVISION 21 – FIRE SUPPRESSION

21 0500 COMMON WORK RESULTS FOR FIRE SUPPRESSION
21 0529 HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING & EQUIPMENT
21 0548 VIBRATION & SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING & EQUIP
21 0553 IDENTIFICATION FOR FIRE-SUPPRESSION PIPING & EQUIPMENT
21 1313 WET-PIPE SPRINKLER SYSTEMS

END OF TABLE OF CONTENTS

SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Submittals.
2. Quality Assurance.
3. Examination.
4. Preparation.
5. Repair/Restoration.
6. Cleaning.
7. Piping Installation.
8. Mechanical sleeve seals.
9. Sleeves.
10. Escutcheons.
11. Grout.
12. Fire-suppression demolition.
13. Supports and anchorages.
14. Operation and Maintenance Manuals

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

B. Product Data:
1. Manufacturer’s catalog data for each manufactured item.
   a. Provide section in submittal for each type of item of equipment. Include Manufacturer’s catalog data of each manufactured item and enough information to show compliance with Contract Document requirements. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.
   b. Include name, address, and phone number of each supplier.
2. Shop Drawings:

a. Schematic control diagrams for each separate fan system, heating system, control panel, etc. Each diagram shall show locations of all control and operational components and devices. Mark correct operating settings for each control device on these diagrams.
b. Diagram for electrical control system showing wiring of related electrical control items such as firestats, fuses, interlocks, electrical switches, and relays. Include drawings showing electrical power requirements and connection locations.
c. Drawing of each temperature control panel identifying components in panels and their function.
d. Other shop drawings required by Division 21 trade Sections.

1.4 COMMON INSTALLATION PROVISIONS

A. Manufacturer's Instructions: Comply with manufacturer's installation instructions and recommendations to extent that those instructions and recommendations are more explicit or stringent than requirements contained in Contract Documents. Notify Architecture of conflicts between manufacturer's installation instructions and contract document requirements prior to proceeding.

B. Provide attachment and connection devices and methods necessary for securing work. Secure work true to line and level. Anchor each product securely in place, accurately located, and aligned with other work. Allow for expansion and building movement.

C. Visual Effects: Provide uniform joint widths in exposed work. Arrange joints in exposed work to obtain best visual effect. Refer questionable choices to architect for final decision.

D. Install each component during weather conditions and project status that will ensure best possible results. Isolate each part of completed construction from incompatible material as necessary to prevent deterioration.

E. Coordinate temporary enclosures with required inspections and tests, to reduce necessity of uncovering completed construction for that purpose.

F. Mounting Heights: Where mounting heights are not shown, install individual components at standard mounting heights recognized within the industry or local codes for that application. Refer questionable mounting height decisions to architect for final decision.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Processes and operators shall comply with AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Processes and operators shall comply with ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS certification tests for welding processes involved and that certification is current.

C. Requirements of Regulatory Agencies:
1. Perform work in accordance with applicable provisions of Plumbing Codes and Gas Ordinances applicable to Project. Provide materials and labor necessary to comply with rules, regulations and ordinances.
2. In case of differences between building codes, laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Notify Architect in writing of such differences before performing work affected by such differences.

D. Identification:
   1. Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Product is turned over to Owner.
   2. Materials shall bear Manufacturer's name and trade name. Equipment and materials of same general type shall be of same make throughout work to provide uniform appearance, operation, and maintenance.

1.6 OPERATION AND MAINTENANCE DATA

A. Summary:
   1. This Section includes administrative and procedure requirements for preparing operation and maintenance manuals, including the following:
      a. Operation manuals for systems, subsystems, and equipment.
      b. Maintenance manuals for the care and maintenance of products, materials, finishes, systems and equipment.

B. Submittals:
   1. Manual: Submit one copy of each manual in final form at least 15 days before final inspection. Architect will return copy with comments within 15 days after final inspection.
      a. Correct or modify each manual to comply with Architect's comments. Submit 3 copies of each corrected manual within 15 days of receipt of Architect's comments.

PART 2 - PRODUCTS

2.1 EXAMINATION:

A. Site Inspection:
   1. Examine premises to understand conditions that may affect performance of work of this Division before submitting proposals for this work. Examine adjoining work on which mechanical work is dependent for efficiency and report work that requires correction.
   2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Drawings:
   1. Plumbing and Mechanical Drawings show general arrangement of piping, ductwork, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
   2. Consider Architectural and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Plumbing and Mechanical Drawings.
   3. Because of scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.

C. Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

2.2 PREPARATION:

A. Check that slots and openings provided under other Divisions through floors, walls, ceilings, and roofs are properly located. Perform cutting and patching caused by neglecting to coordinate with Divisions providing slots and openings at no additional cost to Owner.

B. Changes Due to Equipment Selection:
   1. Where equipment specified or otherwise approved requires different arrangement or connections from that shown in Contract Documents, submit drawings, if requested by Architect, showing proposed installations.
   2. If proposed changes are approved, install equipment to operate properly and in harmony with intent of Contract Documents. Make incidental changes in piping, ductwork, supports, installation, wiring, heaters, panelboards, and as otherwise necessary.
   3. Provide any additional motors, valves, controllers, fittings, and other additional equipment required for proper operation of the system resulting from selection of equipment, including all required changes in affected trades.
   4. Be responsible for the proper location of roughing-in and connections provided under other Divisions.

2.3 REPAIR/RESTORATION:

A. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
   1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown.
   2. Surface finishes shall exactly match existing finishes of same materials.

B. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

2.4 CLEANING:

A. Clean exposed piping, ductwork, equipment, and fixtures. Remove stickers from fixtures and adjust flush valves.

B. No more than one week before Final Inspection, flush out bearings and clean other lubricated surfaces with flushing oil. Provide best quality and grade of lubricant specified by Equipment Manufacturer.

C. Replace filters in equipment for moving air with new filters of specified type no more than one week before Final Inspection.

2.5 PIPING INSTALLATION:

A. Interface With Other Work:
   1. Furnish sleeves, inserts, supports, and equipment that are to be installed by others in sufficient time to be incorporated into construction as work proceeds. Locate these items and see they are properly installed.

B. Furnish and install complete system of piping, valved as indicated or as necessary to completely control entire apparatus.
   1. Pipe drawings are diagrammatic and indicate general location and connections. Piping may have to be offset, lowered, or raised as required or directed at site. This does not relieve this Division from responsibility for proper erection of systems of piping in every respect.

2. Arrange piping to not interfere with removal of other equipment, ducts, or devices, or block access to doors, windows, or access openings.
   a. Arrange so as to facilitate removal of tube bundles.
   b. Provide accessible flanges or ground joint unions, as applicable for type of piping specified, at connections to equipment and on bypasses.
      1) Make connections of dissimilar metals with di-electric unions.
      2) Install valves and unions ahead of traps and strainers. Provide unions on both side of traps.
   c. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running traps.
   d. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running couplings.
   e. Install piping systems so they may be easily drained. Provide drain valves at low points and manual air vents at high points in hot water heating and cooling water piping.
   f. Install piping to insure noiseless circulation.
   g. Place valves and specialties to permit easy operation and access. Valves shall be regulated, packed, and glands adjusted at completion of work before final acceptance.
3. Do not install piping in shear walls.

C. Properly support piping and make adequate provisions for expansion, contraction, slope and anchorage.
   1. Cut piping accurately for fabrication to measurements established at site. Remove burr and cutting slag from pipes.
   2. Work piping into place without springing or forcing. Make piping connections to pumps and other equipment without strain at piping connection. Remove bolts in flanged connections or disconnect piping to demonstrate that piping has been so connected, if requested.
   3. Make changes in direction with proper fittings.
   4. Except for underground pipe, suspend piping from roof trusses or clamp to vertical walls using Unistrut and clamps. Do not hang pipe from other pipe, equipment, or ductwork. Laying of piping on any building element is not allowed.
   5. Supports for Horizontal Piping:
      a. Support metal piping at 96 inches mm on center maximum for pipe 1-1/4 inches or larger and 72 inches on center maximum for pipe 1-1/8 inch or less.
      b. Support thermoplastic pipe at 48 inches on center maximum.
      c. Provide support at each elbow. Install additional support as required.
   6. Supports for Vertical Piping:
      a. Place riser clamps at each floor or ceiling level.
      b. Securely support clamps by structural members, which in turn are supported directly from building structure.
      c. Provide clamps as necessary to brace pipe to wall.
   7. Insulate hangers for copper pipe from piping by means of at least two layers of Scott 33 plastic tape.
   8. Expansion of Thermoplastic Pipe:
      a. Provide for expansion in every 30 feet of straight run.
      b. Provide 12 inch offset below roof line in each vent line penetrating roof.

D. Provide sleeves around pipes passing through concrete or masonry floors, walls, partitions, or structural members. Do not place sleeves around soil, waste, vent, or roof drain lines passing through concrete floors on grade. Seal sleeves with specified sealants.
   1. Sleeves through floors shall extend 1/4 inch above floor finish in mechanical equipment rooms above basement floor. In other rooms, sleeves shall be flush with floor.
   2. Sleeves through floors and foundation walls shall be watertight.

E. Provide spring clamp plates (escutcheons) where pipes run through walls, floors, or ceilings and are exposed in finished locations of building. Plates shall be chrome plated heavy brass of plain pattern and shall be set tight on pipe and to building surface.

2.6 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.7 JOINING MATERIALS

A. Refer to individual Division 21 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

E. Welding Filler Metals: Comply with AWS D10.12.

2.8 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.9 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.10 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

2.11 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.12 OPERATION AND MAINTENANCE MANUALS

A. General:
1. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain a title page, table of contents, and manual contents.
2. Title Page: Enclose title page in transparent plastic sleeve. Include the following information.
   a. Subject matter included in manual.
   b. Name and address of Project.
   c. Name and address of Owner.
   d. Date of submittal.
   e. Name, address, and telephone number of Contractor.
   f. Name and address of Architect.
   g. Cross-reference to related systems in other operation and maintenance manuals.
3. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
4. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
   a. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2 by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
      1) Identify each binder on front and spine, with printed title “OPERATION AND MAINTENANCE MANUAL,” Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
   b. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
   c. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
   d. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

1) If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
2) If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

5. Include copies of approved shop drawings and copies of warranties required in individual Sections of Division 21.

B. Operation Manuals
1. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and equipment descriptions, operating standards, operating procedures, operating logs, wiring and control diagrams, and license requirements.
2. Descriptions: Include the following:
   a. Product name and model number.
   b. Manufacturer's name.
   c. Equipment identification with serial number of each component.
   d. Equipment function.
   e. Operating characteristics.
   f. Limiting conditions.
   g. Performance curves.
   h. Engineering data and tests.
   i. Complete nomenclature and number of replacement parts.
3. Operation Procedures: Include start-up, break-in, and control procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; and required sequences for electric or electronic systems.
4. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
5. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

C. Product Maintenance Manual
1. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.
2. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
3. Product Information: Include the following, as applicable:
   a. Product name and model number.
   b. Manufacturer's name.
   c. Color, pattern, and texture.
   d. Material and chemical composition.
   e. Reordering information for specially manufactured products.
4. Maintenance Procedures: Include manufacturer's written recommendations and inspection procedures, types of cleaning agents, methods of cleaning, schedule for cleaning and maintenance, and repair instructions.
5. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
6. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

D. Systems and Equipment Maintenance Manual

1. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturer's maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
2. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
3. Manufacturer's Maintenance Documentation: Manufacturer's maintenance documentation including maintenance instructions, drawings and diagrams for maintenance, nomenclature of parts and components, and recommended spare parts for each component part or piece of equipment.
4. Maintenance Procedures: Include test and inspection instructions, troubleshooting guide, disassembly instructions, and adjusting instructions, and demonstration and training videotape if available, that detail essential maintenance procedures.
5. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
6. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
7. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
8. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.1 FIRE-SUPPRESSION DEMOLITION

A. Refer to Division 01 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
   1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS:

A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Install steel pipe for sleeves smaller than 6 inches in diameter.
   2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
   3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-Penetration Firestop Systems" for materials.

Q. Verify final equipment locations for roughing-in.

R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to 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 unless dry seal threading is specified.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.5 GROUTING

A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.6 O & M MANUAL PRE-PREPARATION

A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material and finish incorporated into the Work.

B. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

C. Manufacturer's Data: Where manuals contain manufacturer's standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data includes more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

D. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.
   1. Do not use original Project Record Documents as part of operation and maintenance manuals.

E. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 210500

SECTION 210529 - HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:
1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices and seismic restraints.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the licensed professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Certifications: Procedures and personnel shall met requirements according to AWS D1.1/D1.1M.

B. Pipe Welding Certification: Procedures and operators shall be met requirements according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a licensed professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to 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.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

C. NFPA Compliance: Comply with NFPA 13.

D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe and Tube Hangers:
1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

C. University of Utah approved vendor/manufacturer:
1. Anvil International
2. B-Line
3. ITT Grinnel
4. For other products/manufacturers, prior approval is required.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with NFPA-approved, UL-listed, or FM-approved carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL HANGER-SHIELD INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carpenter & Paterson, Inc.
2. National Pipe Hanger Corporation.
3. nVent (CADDY).
4. Pipe Shields Inc.
5. Piping Technology & Products, Inc.
6. Rilco Manufacturing Co., Inc.
7. Value Engineered Products, Inc.

B. Insulation-Insert Material: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate 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.
      d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Eaton (B-line)
      b. Empire Tool and Manufacturing Co., Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      e. MKT Fastening, LLC.
   2. Indoor Applications: Zinc-coated or Stainless steel.
   3. Outdoor Applications: Stainless steel.

2.6 EQUIPMENT SUPPORTS

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

2.7 MATERIALS

A. Aluminum: ASTM B221.

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. 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 078413 "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 present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. 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.

B. 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 from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.
   2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. 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.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. 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. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. 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.

3.3 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 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 because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 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.

3.6 PAINTING

A. Touchup: 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.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099123 "Interior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 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 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 metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use thermal hanger-shield inserts for insulated piping and tubing.

I. 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.
   2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
   3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
   4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
   5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
   6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
   7. 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.
   8. 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.
   9. 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.

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: Comply with NFPA requirements.

L. 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.

M. Saddles and Shields: Comply with NFPA requirements. 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 NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Restraints - cable type.
   2. Restraint accessories.
   3. Post-installed concrete anchors.

B. Includes But Not Limited To:
   1. Quality of and requirements for anchorage and seismic restraint systems and vibration isolation systems for fire sprinkling piping and equipment.

C. Related Requirements:
   1. Furnishing and installing of seismic restraint and vibration isolation systems is by installed of equipment requiring such systems.
      a. Manufacturers of equipment specified to receive restraint shall provide product data needed for calculation of seismic restraint needs. This information shall include, but not be limited to, equipment dimensions, dimensioned anchor points, operating weight, and center of gravity dimension.
   2. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.
   3. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in ASCE, Section 9.4.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
   3. Category I:
      a. Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: Agricultural facilities, certain temporary facilities, minor storage facilities.
   4. Category II:
      a. All buildings and other structures except those listed in Categories I, III, and IV.
   5. Category III:
      a. Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to:
         1) Buildings and other structures where more than 300 people congregate in one area.
         2) Buildings and other structures with day care facilities with capacity greater than 150.
         3) Buildings and other structures with elementary school or secondary school facilities with capacity greater than 250.
         4) Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities.
         5) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities.
         6) Jails and detention facilities.

7) Power generating stations and other public utility facilities not included in Category IV.

b. Buildings and other structures not included in Category IV (including, but not limited to, facilities that manufacturer, process, handle, store, use or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials to be dangerous to the public if released.

6. Category IV:
   a. Buildings and other structures designated as essential facilities including, but not limited to:
      1) Hospitals and other health care facilities having surgery or emergency treatment facilities.
      2) Fire, rescue, ambulance, and police stations and emergency vehicle garages.
      3) Designated earthquake, hurricane, or other emergency shelters.
      4) Designated emergency prepardness, communication, and operation centers and other facilities required for emergency response.
      5) Power generating stations and other public utility facilities required in an emergency.
      6) Ancillary structures (including, but not limited to, communication towers fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Category IV structures during an emergency.
      7) Aviation control towers, air traffic control centers, and emergency aircraft hangers.
      8) Water storage facilities and pump structures required to maintain water pressure for fire suppression.
      9) Buildings and other structures having critical national defense functions.
   b. Buildings and other structures (including, but not limited to, facilities that manufacturer, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemical, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction.
   c. Component Importance Factor: As per ASCE, Section 9.6.
   d. Component Response Modification Factor: As per ASCE, Section 9.6.
   e. Component Amplification Factor: As per ASCE, Section 9.6.
7. Design Spectral Response Acceleration at Short Periods (0.2 Second): As per ASCE, Section 9.4.
8. Design Spectral Response Acceleration at 1-Second Period: As per ASCE, Section 9.4.

B. This Section includes vibration isolation and seismic resistant for the following:
   1. All mechanical equipment 0.75 horsepower and over listed in the equipment schedule shall be mounted on vibration isolators to prevent the transmission of objectionable vibration and vibration induced sound to the building structure.
      a. All isolation materials, flexible connectors and seismic restraints shall be of the same manufacturer and shall be selected and certified using published or factory certified data. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
   2. Install full line size flexible pipe connectors at the inlet and outlet of each pump, cooling tower, condenser, chiller, coiling connections of where shown on the drawings. All connectors shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit

elongation to 3/8 inch. Flexible connectors shall not be required for suspended in-line pumps.

3. Unless otherwise specified, all mechanical, electrical and plumbing equipment, pipe, and duct shall be restrained to resist seismic forces. Restraint devices shall be designed and selected to meet the seismic requirements as defined in the latest issue of the IBC or local jurisdiction building code. Equipment importance factors are determined as follows:
   a. $I_p = 1.5$ Life-safety component is required to function after an earthquake.
   b. $I_p = 1.5$ Component contains hazardous or flammable material.
   c. $I_p = 1.5$ Storage racks in occupancies open to th general public (e.g., warehouse retail stores).
   d. $I_p = 1.5$ All other components.

C. Seismic Restraint Shall Not Be Required for the Following:
   1. Rigidly floor mounted mechanical and plumbing components in all seismic design categories, where I_p = 1.0 and flexible connections between the components and associated duct work, piping and conduit are provided, that are mounted at 4 feet or less above a floor level and weight 400 pounds or less and are not critical to the continued operation of the structure. Suspended, wall mounted and flexibly mounted equipment are not included in this exclusion.
   2. Hanging, wall mounted, and flexibly supported mechanical, plumbing, and electrical components that weigh 20 pounds or less, where $i_p = 1.0$ and flexible connections between the components and associated duct work, piping and conduit.
   3. Piping supported by individual clevis hangers where the distance, as measured from the top of the pipe to the supporting structure, is less than 12 inches for the entire pipe run and the pipe can accommodate the expected deflections. Trapeze or double rod hangers where the distance from the top of the trapeze or support to the structure is less than 12 inches for the entire run. Hanger rods shall be constructed in a manner that would subject the rod to bending moments (swivel, eye bolt, or vibration isolation hanger connection to structure).
   4. High deformability piping (steel, copper, aluminum with welded, brazed, ground, or screwed connections) designated as having an $I_p = 1.5$ and a nominal pipe size of 1 inch or less where provisions are made to protect the piping from impact or to avoid the impact of larger piping or other mechanical equipment. Note, any combination of piping supported on a trapeze where the total weight exceeds 10 pounds per foot must be braced.
   5. High deformability piping (steel, copper, aluminum with welded, brazed, ground or screwed connections) and limited deformability piping (cast iron, FRP, PVC) designated with an $I_p = 1.0$ and a nominal pipe size of 1-inch and less in the mechanical equipment room, or 2-inch and less outside the mechanical equipment room.
   6. PVC or other plastic or fiberglass vent piping.
   7. HVAC ducts suspended from hangers that are 12 inches or less in length from the top of the duct to the supporting structure and the hangers are detailed to avoid significant bending of the hangers and their connections. Duct must be positively attached to hanger with minimum #10 screws within 2 inches from the top of the duct.
   8. HVAC duct with an $I_p = 1.5$ that have a cross-section area less than 4 square feet. HVAC ducts with an $I_p = 1.0$ that have a cross sectional area of less than 6 square feet.
   9. Equipment items installed in-line with the duct system (e.g., fans, heat exchangers and humidifiers) with an operating weight less than 76 pounds. Equipment must be rigidly attached to duct at inlet and outlet.

D. Manufacturer's Responsibilities: Manufacturer of vibration and seismic control products shall have the following responsibilities:
   1. Determine vibration isolation and seismic restraint sizes and locations.
   2. Provide piping, ductwork and equipment isolation systems and seismic restraints as schedule or specified.

3. Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.
4. Provide calculations to determine restraint loads resulting from seismic forces presented in local building code. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum 5 years' experience. Provide calculations for all floor or roof-mounted equipment 400 pounds or greater (20 pounds or greater for I_p = 1.5), all suspended or wall mounted equipment 20 pounds or greater, and vibration isolated equipment 20 pounds or greater.
5. Seismic restraint load ratings must be certified and substantiated by testing or calculations under direct control of a registered professional engineer.
6. Calculations and restraint device submittal drawings shall specify anchor bolt type, embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Concrete anchor locations shall not be near edges, stress joints, or an existing fracture. All bolts shall be ASTM A307 or better.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.
2. 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 Submittal:
1. For each seismic-restraint device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
   a. Seismic-Restraint Selection: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
   b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
   c. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
   d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
   e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" in "Performance Requirements" Article.
   f. Licensed Professional Engineer: All designated-design submittals for seismic calculations are to be signed and sealed by licensed professional engineer responsible for their preparation.
2. Seismic-Restraint Detail Drawing:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and

values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic restraint details with wind-load restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.

3. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
4. All delegated-design submittals for seismic-restraint detail Drawings are to be signed and sealed by licensed professional engineer responsible for their preparation.

D. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Welding certificates.

C. Field quality-control reports.

D. Seismic Certification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-16, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.

1. Provide equipment manufacturer's written certification for each designated active fire-suppression system seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction or experience data as permitted by ASCE/SEI 7-16.
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-16.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
4. The following fire-suppression system systems and components are Designated Seismic Systems and require written special certification of seismic certification by manufacturer:

E. Wind-Load Performance Certification: Provide special certification for fire-suppression system components subject to high-wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-load performance certification.

1. Provide equipment manufacturer's written certification for each designated fire-suppression system device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
2. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction
3. The following fire-suppression system systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind load and impact damage must be provided by manufacturer.

1.5 QUALITY ASSURANCE

A. Testing Agency Certifications: An independent agency, with the experience and capability to conduct testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Welding Certifications: Procedures and personnel shall comply with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. CADDY; a brand of nVent.
   3. California Dynamics Corporation
   4. Hilti, Inc.
   5. Isolation Technology, Inc.
   6. TOLCO
   7. Unistrut; Part of Atkore International
   8. Vibration Mountings & Controls, Inc.
   9. Vibro-Acoustics

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.

2.2 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-Line, an Eaton business.
   2. CADDY; a brand of nVent
   3. Loos & Co.
   4. Vibration Mountings & Controls, Inc.
   5. Vibro-Acoustics

B. Seismic-Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. 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.

2.3 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. CADDY; a brand of nVent
   3. Hilti, Inc.
   4. Loos & Co.
   5. Mason Industries, Inc.
   6. TOLCO
   7. Unistrut; Part of Atkore International
   8. Vibro-Acoustics

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid restraints 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.

2.4 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-line, an Eaton business.
      b. Hilti, Inc.
      c. Mason Industries, Inc.
      d. Power Fasteners.
      e. Simpson Strong-Tie Co., Inc.
      f. Unistrut; Part of Atkore International.
   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. Provide post-installed concrete anchors that have been precertified for use in seismic applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16 Ch. 13.
   1. Precertify post-installed anchors in concrete in accordance with ACI 355.2 or other approved certification testing procedures.
   2. Precertify post-installed anchors in masonry in accordance with approved certification procedures.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
   1. Undercut expansion anchors are permitted.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry calculated static and seismic loads within specified loading limits.

3.2 INSTALLATION OF VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Fire-Suppression Vibration Isolation, Seismic, and Wind-Load-Restraint Schedule, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint devices for systems and equipment where indicated in Equipment Schedules or Vibration Isolation, Seismic, and Wind-Load-Restraint Schedules, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

D. Installation of vibration isolators and seismic restraints must not cause any stresses, misalignment, or change of position of equipment or piping.

E. Comply with installation requirements of NFPA 13 for installation of all seismic-restraint devices.

F. Comply with requirements in Section 077200 "Roof Accessories" for installation of equipment supports and roof penetrations.

G. Equipment Restraints:
   1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

H. Piping Restraints:
   1. Comply with all requirements in NFPA 13.
   2. Design piping sway bracing in accordance with NFPA 13.
      a. Maximum spacing of all sway bracing to be no greater than indicated in NFPA 13.
      b. Design loading of all sway bracing not to exceed values indicated in NFPA 13.

I. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

J. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

K. 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.

L. 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.

M. 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 the 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. Mechanical-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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 INSTALLATION

A. Comply with manufacturer’s instructions for the installation and load application of vibration isolation materials and products. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary support during installation or shipping.

B. Locate isolation hangers as near the overhead support structure as possible.

C. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

D. Install isolated inertia based frames and steel bases on isolator units as indicated so that a minimum of 2-inch clearance below base will result when supported equipment has been installed and loaded for operation.

E. Roof curbs shall be installed directly to building structural steel or concrete roof deck. Installation on top of steel deck or roofing material is not acceptable.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross structural seismic joints and other points where differential movement may occur, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" 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. Testing Agency: Engage a certified testing agency to perform tests and inspections.

B. 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 postconnection 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 no fewer than 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 210548

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

PART 2 - PRODUCTS

2.1 IDENTIFICATION

A. Equipment and Pipe Identification:
   1. All fire sprinkling systems shall be labeled.
      a. Valve tags shall be connected to valve stems by steel rings and include the following minimum information:
         1) Plan identification.
         2) Normal position.
         3) Duty.
         4) Area served.
         5) Valve type.
   2. All accessible piping shall be color coded and identified with working and arrows every 50 feet, at each riser, at each junction, at each access door, and where required to easily identify the medium transported.
   3. Piping systems shall be identified by:
      a. Background color.
      b. Lettering color.
      c. Flow direction arrow.
   4. Piping background color shall be applied to all exposed piping (either over bare pipe or the insulation) in mechanical rooms. Identifying lettering and arrows shall then be added as indicated above, and as necessary to be visible from anywhere in the room.
      a. For chases, and other exposed areas, as well as piping routed in other exposed areas such as chases, background color shall be applied in a two foot (2’-0”) wide band with identifying lettering and a flow direction arrow.
      b. Background and lettering shall be semi-gloss enamel paint. The colors specified herein shall not vary.

COLOR	SHERWIN WILLIAMS	PRATT & LAMBERT	RUST-OLEUM
Red	SW4081 Safety Red	1007 Vibrant Red	964 Federal Safety Red
Orange	SW4083 Safety Orange	S4507 Safety Orange	956 Federal Safety Orange
Yellow	SW4084 Safety Yellow	1732 Spectrum Yellow	944 Federal Safety Yellow
Green	SW4085 Safety Green	Safety Green	933 Federal Safety Green

Blue	SW4086 Safety Blue	1228 Anchors Aweigh	925 Federal Safety Blue
Purple	SW4080 Plum	Bright Medium	Bright Medium
Silver (Aluminum)	B59S11 Silver Brite	-	-
Black	Black	Effecto Black	634 Black
White	White	Effecto White	2766 White
Brown	SW4001 Bolt Brown	2278 Char Brown	-
University experience has shown that Mirrolac works well in this application, being durable with excellent coverage.			

c. Identifying lettering shall be painted or stenciled on pipe over the background color. Self-adhesive or glue-on type labels are acceptable. Letters shall be 2” high for duct and larger piping 3” or more, 1” high for 1-1/4” to 2-1/2” pipe, and 1/2” high for 1” pipe and smaller.

d. Arrows to indicate direction of flow shall be painted over the background color in the same color as the lettering. The arrow shall point away from the lettering. On duct and large piping 3” or more in diameter, the “shaft” of the arrow shall be 2” long and 1” wide. Smaller piping, 2-1/2” or less, shall have arrows with a shaft 1/2” wide and 2” long. Use a double-headed arrow if the flow can be in either direction.

e. Piping shall be identified with the following colors:

MEDIUM IN PIPE	BACKGROUND COLOR	IDENTIFYING LETTERING	LETTERING COLOR
WATER **NOTE: DIRECTIONAL ARROWS ARE REQUIRED ON HTW PIPING			
Fire Protection Water	Red	Fire Protection	White

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. 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. Piping Color Coding: Painting of piping is specified in Section 099123 “Interior Painting.”

B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

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 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.

D. Flow- Direction Arrows: Provide arrows to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

E. Fire-Suppression Pipe Label Color Schedule:
   1. Fire-Suppression Pipe Labels: White letters on an ANSI Z535.1 safety-red background.

END OF SECTION 210553

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipes, fittings, and specialties.
   2. Sprinklers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For wet-pipe sprinkler systems.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the designer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, or BIM model, drawn to scale, on which items of other systems and equipment are shown and coordinated with each other, using input from installers of the items involved.

B. Design Data:
   1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

C. Field Test Reports: 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."

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Certifications:
   1. Installer's responsibilities include designing, fabricating, and installing sprinkler 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 a licensed professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a certified testing agency, and marked for intended location and application.

B. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with NFPA 13.

C. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.

D. Delegated Design: Engage a designer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
   1. Sprinkler system design shall be approved by authorities having jurisdiction.
      a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
      b. Sprinkler Occupancy Hazard Classifications:
         1) Automobile Parking Areas: Ordinary Hazard, Group 1.
         2) Building Service Areas: Ordinary Hazard, Group 1.
         3) Churches: Light Hazard.
         4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
         5) Dry Cleaners: Ordinary Hazard, Group 2.
         6) Elevator Machine Room and Hoistway: Ordinary Hazard, Group 1.
         7) General Storage Areas: Ordinary Hazard, Group 1.
         8) Laundries: Ordinary Hazard, Group 1.
         9) Libraries except Stack Areas: Light Hazard.
         10) Library Stack Areas: Ordinary Hazard, Group 2.
         11) Machine Shops: Ordinary Hazard, Group 2.
         12) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
         13) Office and Public Areas: Light Hazard.
         14) Plastics Processing Areas: Extra Hazard, Group 2.
         15) Printing Plants: Extra Hazard, Group 1.
         16) Repair Garages: Ordinary Hazard, Group 2.
         17) Residential Living Areas: Light Hazard.
         18) Restaurant Service Areas: Ordinary Hazard, Group 1.
         19) Solvent Cleaning Areas: Extra Hazard, Group 2.
         20) Upholstering Plants: Extra Hazard, Group 1.
   2. Minimum Density for Automatic-Sprinkler Piping Design:
      a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
      b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
      c. Ordinary-Hazard, Group 2 Occupancy: [0.20 gpm over 1500-sq. ft. area.
   3. Maximum protection area per sprinkler according to UL listing.

E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

F. Materials, devices and equipment shall be Underwriters Laboratory listed or Factory Mutual approved for use in the fire protection systems.

G. Designer shall be a Registered Fire Protection Engineer, or shall be certified as an Engineering Technician or Senior Engineering Technician (Level III or Level IV), National Institute for Certification in Engineering Technologies (NICET), Automatic Sprinkler System Layout.

H. Installer shall be a state licensed fire sprinkler system contractor.

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A53/A53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Galvanized- and Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

D. Galvanized- and Uncoated-Steel Couplings: ASTM A865/A865M, threaded.

E. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.

G. Cast-Iron Flanges: ASME 16.1, Class 125.

H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
   1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic and asbestos free] [or] [EPDM rubber gasket.
      a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
      b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

I. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Victaulic Company.
   2. Pressure Rating: 175-psig minimum.
   3. Painted Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
   4. 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.

2.3 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AGF Manufacturing, Inc.
      b. Anvil International.
      c. National Fittings, Inc.
      d. Shurjoint-Apollo Piping Products USA Inc.
      e. Tyco by Johnson Controls Company.
      f. 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. Branch Line Testers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AGF Manufacturing, Inc.
   b. Elkhart Brass Mfg. Co., Inc.
   c. Fire-End & Croker Corporation.
   d. Potter Electric Signal Company, LLC.
   e. 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.

C. Sprinkler Inspector's Test Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AGF Manufacturing, Inc.
   b. Triple R Specialty.
   c. Tyco by Johnson Controls Company.
   d. Victaulic Company.
   e. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "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.

D. Adjustable Drop Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Aegis Technologies, Inc.
   b. CACA, LLC.
   c. CPS Products, Inc.
   d. Merit Manufacturing.
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.

E. Flexible Sprinkler Hose Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ALEUM USA.

b. FlexHead Industries, Inc.
c. Gateway Tubing, Inc.
d. Victaulic Company.
2. Standard: UL 1474.
3. Type: 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.

2.4 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Globe Fire Sprinkler Corporation.
2. Reliable Automatic Sprinkler Co., Inc. (The).
3. Tyco by Johnson Controls Company.
4. Venus Fire Protection Ltd.
5. Victaulic Company.
6. Viking Corporation.

B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

C. Pressure Rating for Residential Sprinklers: 175-psig maximum.

D. Pressure Rating for Automatic Sprinklers: 175-psig minimum.

E. Automatic Sprinklers with Heat-Responsive Element:
1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. 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.

F. Sprinkler Finishes: Chrome plated, bronze and painted.

G. Special Coatings: Wax and corrosion-resistant paint.

H. 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: Plastic, white finish, one piece, flat.
2. Sidewall Mounting: Plastic, white finish, one piece, flat.

I. Sprinkler Guards:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Reliable Automatic Sprinkler Co., Inc. (The).
b. Tyco by Johnson Controls Company.
c. Victaulic Company.
d. Viking Corporation.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

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 authorities having jurisdiction. 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 sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

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 outside building.

J. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

K. Fill sprinkler system piping with water.

L. Do not install piping in areas subject to freezing.

3.2 JOINT CONSTRUCTION

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 according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to 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, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.3 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 or NFPA 13R for supports.

3.4 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels. Plus or minus 2”.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.5 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 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 sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   4. Energize circuits to electrical equipment and devices.

5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.
7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 CLEANING

A. Clean dirt and debris from sprinklers.

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.

3.8 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.

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

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be one of the following:
1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 shall be one of the following:
1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

E. Standard-pressure, wet-pipe sprinkler system, NPS 5, shall be one of the following:
1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.9 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright sprinklers.
5. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.
   1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
   2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
   3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
   4. Residential Sprinklers: Dull chrome.
   5. Upright Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

TABLE OF CONTENTS

DIVISION 22 - PLUMBING

22 0500	COMMON WORK RESULTS FOR PLUMBING
22 0523.12	BALL VALVES FOR PLUMBING PIPING
22 0529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 0548	VIBRATION & SEISMIC CONTROLS FOR PLUMBING AND EQUIPMENT
22 0553	IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
22 0719	PLUMBING PIPING INSULATION
22 0800	COMMISSIONING OF PLUMBING SYSTEMS
22 1116	DOMESTIC WATER PIPING **(Copper)**
22 1119	DOMESTIC WATER PIPING SPECIALTIES
22 6113	COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES
22 6119	COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES
22 6213	VACUUM PIPING FOR LABORATORY FACILITIES
22 6600	CHEMICAL-WASTE SYSTEMS FOR LABORATORY & HEALTHCARE FACILITIES
22 6700	PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

END OF TABLE OF CONTENTS

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Submittals.
2. Quality Assurance
3. Examination.
4. Preparation.
5. Repair/Restoration.
6. Cleaning.
7. Piping Installation.
8. Dielectric fittings.
9. Mechanical sleeve seals.
10. Sleeves.
11. Escutcheons.
12. Grout.
13. Plumbing demolition.
14. Equipment installation requirements common to equipment sections.
15. Supports and anchorages.
16. Operation and Maintenance Manuals

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than plumbing and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and plumbing equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

B. Product Data:
1. Manufacturer's catalog data for each manufactured item.
   a. Provide section in submittal for each type of item of equipment. Include Manufacturer's catalog data of each manufactured item and enough information to show compliance with Contract Document requirements. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.
   b. Include name, address, and phone number of each supplier.

C. Shop Drawings:
   1. Schematic control diagrams for each separate fan system, heating system, control panel, etc. Each diagram shall show locations of all control and operational components and devices. Mark correct operating settings for each control device on these diagrams.
   2. Diagram for electrical control system showing wiring of related electrical control items such as firestats, fuses, interlocks, electrical switches, and relays. Include drawings showing electrical power requirements and connection locations.
   3. Drawing of each temperature control panel identifying components in panels and their function.
   4. Other shop drawings required by Division 22 trade Sections.

1.4 COMMON INSTALLATION PROVISIONS

A. Manufacturer's Instructions: Comply with Manufacturer's installation instructions and recommendations to extent that those instructions and recommendations are more explicit or stringent than requirements contained in Contract Documents. Notify Architect of conflicts between Manufacturer's installation instructions and contract documents requirements prior to proceeding.

B. Provide attachment and connection devices and methods necessary for securing work. Secure work true to line and level. Anchor each product securely in place, accurately located, and aligned with other work. Allow for expansion and building movement.

C. Visual Effects: Provide uniform joint widths in exposed work. Arrange joints in exposed work to obtain best visual effect. Refer questionable choices to Architect for final decision.

D. Install each component during weather conditions and project status that will ensure best possible results. Isolate each part of completed construction from incompatible material as necessary to prevent deterioration.

E. Coordinate temporary enclosures with required inspections and tests, to reduce necessity of uncovering completed construction for that purpose.

F. Mounting Heights: Where mounting heights are not shown, install individual components at standard mounting heights recognized within the industry or local codes for that application. Refer questionable mounting height decisions to Architect for final decision.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: For processes and operators shall comply with AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: For processes and operators shall comply with ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS certifications tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

D. Requirements of Regulatory Agencies:

1. Perform work in accordance with applicable provisions of Plumbing Codes and Gas Ordinances applicable to Project. Provide materials and labor necessary to comply with rules, regulations and ordinances.
2. In case of differences between building codes, laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Notify Architect in writing of such differences before performing work affected by such differences.

E. Identification:
1. Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Product is turned over to Owner.
2. Materials shall bear Manufacturer's name and trade name. Equipment and materials of same general type shall be of same make throughout work to provide uniform appearance, operation, and maintenance.

1.6 OPERATION AND MAINTENANCE DATA

A. Summary:
1. This Section includes administrative and procedure requirements for preparing operation and maintenance manuals, including the following:
   a. Operation manuals for systems, subsystems, and equipment.
   b. Maintenance manuals for the care and maintenance of products, materials, finishes, systems and equipment.

B. Submittals:
1. Manual: Submit one copy of each manual in final form at least 15 days before final inspection. Architect will return copy with comments within 15 days after final inspection.
   a. Correct or modify each manual to comply with Architect's comments. Submit 3 copies of each corrected manual within 15 days of receipt of Architect's comments.

PART 2 - PRODUCTS

2.1 EXAMINATION:

A. Site Inspection:
1. Examine premises to understand conditions that may affect performance of work of this Division before submitting proposals for this work. Examine adjoining work on which mechanical work is dependent for efficiency and report work that requires correction.
2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Drawings:
1. Plumbing and Mechanical Drawings show general arrangement of piping, ductwork, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
2. Consider Architectural and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Plumbing and Mechanical Drawings.
3. Because of scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.

C. Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified

items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

2.2 PREPARATION:

A. Check that slots and openings provided under other Divisions through floors, walls, ceilings, and roofs are properly located. Perform cutting and patching caused by neglecting to coordinate with Divisions providing slots and openings at no additional cost to Owner.

B. Changes Due to Equipment Selection:
   1. Where equipment specified or otherwise approved requires different arrangement or connections from that shown in Contract Documents, submit drawings, if requested by Architect, showing proposed installations.
   2. If proposed changes are approved, install equipment to operate properly and in harmony with intent of Contract Documents. Make incidental changes in piping, ductwork, supports, installation, wiring, heaters, panelboards, and as otherwise necessary.
   3. Provide any additional motors, valves, controllers, fittings, and other additional equipment required for proper operation of the system resulting from selection of equipment, including all required changes in affected trades.
   4. Be responsible for the proper location of roughing-in and connections provided under other Divisions.

2.3 REPAIR/RESTORATION:

A. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
   1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown.
   2. Surface finishes shall exactly match existing finishes of same materials.

B. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

2.4 CLEANING:

A. Clean exposed piping, ductwork, equipment, and fixtures. Remove stickers from fixtures and adjust flush valves.

B. No more than one week before Final Inspection, flush out bearings and clean other lubricated surfaces with flushing oil. Provide best quality and grade of lubricant specified by Equipment Manufacturer.

C. Replace filters in equipment for moving air with new filters of specified type no more than one week before Final Inspection.

2.5 PIPING INSTALLATION:

A. Interface With Other Work:
   1. Furnish sleeves, inserts, supports, and equipment that are to be installed by others in sufficient time to be incorporated into construction as work proceeds. Locate these items and see they are properly installed.

B. Furnish and install complete system of piping, valved as indicated or as necessary to completely control entire apparatus.

1. Pipe drawings are diagrammatic and indicate general location and connections. Piping may have to be offset, lowered, or raised as required or directed at site. This does not relieve this Division from responsibility for proper erection of systems of piping in every respect.
2. Arrange piping to not interfere with removal of other equipment, ducts, or devices, or block access to doors, windows, or access openings.
    a. Arrange so as to facilitate removal of tube bundles.
    b. Provide accessible flanges or ground joint unions, as applicable for type of piping specified, at connections to equipment and on bypasses.
        1) Make connections of dissimilar metals with di-electric unions.
        2) Install valves and unions ahead of traps and strainers. Provide unions on both sides of traps.
    c. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running traps.
    d. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running couplings.
    e. Install piping systems so they may be easily drained. Provide drain valves at low points and manual air vents at high points in hot water heating and cooling water piping.
    f. Install piping to insure noiseless circulation.
    g. Place valves and specialties to permit easy operation and access. Valves shall be regulated, packed, and glands adjusted at completion of work before final acceptance.
3. Do not install piping in shear walls.

C. Properly support piping and make adequate provisions for expansion, contraction, slope and anchorage.
1. Cut piping accurately for fabrication to measurements established at site. Remove burr and cutting slag from pipes.
2. Work piping into place without springing or forcing. Make piping connections to pumps and other equipment without strain at piping connection. Remove bolts in flanged connections or disconnect piping to demonstrate that piping has been so connected, if requested.
3. Make changes in direction with proper fittings.
4. Except for underground pipe, suspend piping from roof trusses or clamp to vertical walls using Unistrut and clamps. Do not hang pipe from other pipe, equipment, or ductwork. Laying of piping on any building element is not allowed.
5. Supports for Horizontal Piping:
    a. Support metal piping at 96 inches mm on center maximum for pipe 1-1/4 inches or larger and 72 inches on center maximum for pipe 1-1/8 inch or less.
    b. Support thermoplastic pipe at 48 inches on center maximum.
    c. Provide support at each elbow. Install additional support as required.
6. Supports for Vertical Piping:
    a. Place riser clamps at each floor or ceiling level.
    b. Securely support clamps by structural members, which in turn are supported directly from building structure.
    c. Provide clamps as necessary to brace pipe to wall.
7. Insulate hangers for copper pipe from piping by means of at least two layers of Scott 33 plastic tape.
8. Sleeves through floors shall extend 1/4 inch above floor finish in mechanical equipment rooms above basement floor. In other rooms, sleeves shall be flush with floor.
9. Sleeves through floors and foundation walls shall be watertight.

D. Provide spring clamp plates (escutcheons) where pipes run through walls, floors, or ceilings and are exposed in finished locations of building. Plates shall be chrome plated heavy brass of plain pattern and shall be set tight on pipe and to building surface.

2.6 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.7 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

2.8 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.9 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.10 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.11 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

2.12 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.13 OPERATION AND MAINTENANCE MANUALS

A. General:
   1. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain a title page, table of contents, and manual contents.
   2. Title Page: Enclose title page in transparent plastic sleeve. Include the following information.
      a. Subject matter included in manual.
      b. Name and address of Project.
      c. Name and address of Owner.
      d. Date of submittal.
      e. Name, address, and telephone number of Contractor.
      f. Name and address of Architect.
      g. Cross-reference to related systems in other operation and maintenance manuals.

3. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
4. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
    a. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2 by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
        1) Identify each binder on front and spine, with printed title “OPERATION AND MAINTENANCE MANUAL,” Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
    b. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
    c. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
    d. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
        1) If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
        2) If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.
5. Include copies of approved shop drawings and copies of warranties required in individual Sections of Division 22.

B. Operation Manuals
1. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and equipment descriptions, operating standards, operating procedures, operating logs, wiring and control diagrams, and license requirements.
2. Descriptions: Include the following:
    a. Product name and model number.
    b. Manufacturer’s name.
    c. Equipment identification with serial number of each component.
    d. Equipment function.
    e. Operating characteristics.
    f. Limiting conditions.
    g. Performance curves.
    h. Engineering data and tests.
    i. Complete nomenclature and number of replacement parts.
3. Operation Procedures: Include start-up, break-in, and control procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; and required sequences for electric or electronic systems.
4. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
5. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

C. Product Maintenance Manual
1. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

2. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
3. Product Information: Include the following, as applicable:
   a. Product name and model number.
   b. Manufacturer's name.
   c. Color, pattern, and texture.
   d. Material and chemical composition.
   e. Reordering information for specially manufactured products.
4. Maintenance Procedures: Include manufacturer's written recommendations and inspection procedures, types of cleaning agents, methods of cleaning, schedule for cleaning and maintenance, and repair instructions.
5. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
6. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

D. Systems and Equipment Maintenance Manual
1. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturer's maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
2. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
3. Manufacturer's Maintenance Documentation: Manufacturer's maintenance documentation including maintenance instructions, drawings and diagrams for maintenance, nomenclature of parts and components, and recommended spare parts for each component part or piece of equipment.
4. Maintenance Procedures: Include test and inspection instructions, troubleshooting guide, disassembly instructions, and adjusting instructions, and demonstration and training videotape if available, that detail essential maintenance procedures.
5. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
6. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
7. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
8. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

A. Refer to Division 01 Sections "Cutting and Patching" and Division 02 Section "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-Penetration Firestop Systems" for materials.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to 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 unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using certified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

B. Field Welding: Comply with AWS D1.1.

3.7 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8 O & M MANUAL PREPREPARATION

A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material and finish incorporated into the Work.

B. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

C. Manufacturer's Data: Where manuals contain manufacturer's standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data includes more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

D. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.
   1. Do not use original Project Record Documents as part of operation and maintenance manuals.

E. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 220500

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Brass ball valves.
   2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.
   1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
   1. ASME B1.20.1 for threads for threaded end valves.
   2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
   3. ASME B16.18 for solder-joint connections.
   4. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
   2. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:
   1. Include 2-inch stem extensions.
   2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
   3. Memory stops that are fully adjustable after insulation is applied.

I. Ball valves shall be Class 250 rated, with bronze construction, bubble tight PTFE seats, with hard chrome plated brass or stainless steel ball.

J. Valves shall be domestically manufactured.

2.2 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Flow Controls; Conbraco Industries, Inc.
      b. NIBCO INC.
      c. WATTS B – 6080 (Basis of U of U Standard)
   2. Description:
      a. Standard: MSS SP-110 or MSS-145.
      b. CWP Rating: 600 psig.
      c. Body Design: Two piece.
      d. Body Material: Bronze.
      e. Ends: Threaded and soldered.
      f. Seats: PTFE.
      g. Stem: Bronze or brass.
      h. Ball: Chrome-plated brass.
      i. Port: Full.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Valve stem installation to be horizontal or higher than the valve.

3.2 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 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Steel Piping, NPS 2 and Smaller: Threaded ends.

3.3 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze ball valves, two-piece with full port and bronze or brass trim.

3.4 DOMESTIC AND INDUSTRIAL HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze ball valves, two-piece with full port and bronze or brass trim. Provide with threaded or solder-joint ends.

END OF SECTION 220523.12

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Pipe-positioning systems.

B. Related Requirements:
1. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the certified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding: Procedures and personnel shall comply with AWS D1.1/D1.1M.

B. Pipe Welding: Procedures and operators shall comply with "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a licensed professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to 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.
3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
   3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
   4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:
   1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:
   1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

D. University of Utah approved vendor/manufacturer:
   1. Anvil International
   2. B-Line
   3. ITT Grinnel
   4. For other products/manufacturers, prior approval is required.

2.3 TRAPEZE PIPE HANGERS

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 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate 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.
   d. Simpson Strong-Tie Co., Inc.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. B-Line, an Eaton Business.
      b. Empire Tool and Manufacturing Co., Inc.
      c. Hilti, Inc.
      d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
      e. MKT Fastening, LLC.
   2. Indoor Applications: Zinc-coated steel.
   3. Outdoor Applications: Stainless steel.

2.6 PIPE-POSITIONING SYSTEMS

A. 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.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.8 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, 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 078413 "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 present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. 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 from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. 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.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. 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. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. 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.

L. 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. Option: Thermal hanger-shield inserts may be used. 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 shall span an arc of 180 degrees.
   a. Option: Thermal hanger-shield inserts may be used. 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: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 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 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 because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 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.

3.6 PAINTING

A. Touchup: 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.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in “Section 099123 "Interior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 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 and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal hanger-shield inserts for insulated piping and tubing.

J. 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 occurs.
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 occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs 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 occurs 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, in addition to expansion and contraction, is required.

K. 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.

L. 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.

M. 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-joist 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.

N. 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.

O. 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.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

R. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Quality of and requirements for anchorage and seismic restraint systems and vibration isolation systems for plumbing piping and equipment.

B. Delegated Design: Engage a licensed professional engineer to design seismic control system.
   1. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7-16.

C. Related Requirements:
   1. Furnishing and installing of seismic restraint and vibration isolation systems is by installer of equipment requiring such systems.
      a. Manufacturers of equipment specified to receive seismic restraint shall provide product data needed for calculation of seismic restraint needs. This information shall include, but not be limited to, equipment dimensions, dimensioned anchor points, operating weight, and center of gravity dimension.
   2. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
   3. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

D. Section Includes:
   1. Restraints - rigid type.
   2. Restraints - cable type.
   3. Restraint accessories.
   4. Post-installed concrete anchors.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in ASCE, Section 9.4.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC III.
   3. Category I:
      a. Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: Agricultural facilities, certain temporary facilities, minor storage facilities.
   4. Category II:
      a. All buildings and other structures except those listed in Categories I, III and IV.
   5. Category III:
      a. Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to:
         1) Buildings and other structures where more than 300 people congregate in one area.
         2) Buildings and other structures with day care facilities with capacity greater than 150.
         3) Buildings and other structures with elementary school or secondary school facilities with capacity greater than 250.

4) Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities.
5) Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities.
6) Jails and detention facilities.
7) Power generating stations and other public utility facilities not included in Category IV.

b. Buildings and other structures not included in Category IV (including, but not limited to, facilities that manufacturer, process, handle, store, use or dispose of such substances as hazard fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials to be dangerous to the public if released.

6. Category IV:
   a. Buildings and other structures designated as essential facilities including, but not limited to:
      1) Hospitals and other health care facilities having surgery or emergency treatment facilities.
      2) Fire, rescue, ambulance, and police stations and emergency vehicle garages.
      3) Designated earthquake, hurricane, or other emergency shelters.
      4) Designated emergency prepardness, communication and operation centers and other facilities required for emergency response.
      5) Power generating stations and other public utility facilities required in an emergency.
      6) Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Category IV structures during an emergency.
      7) Aviation control towers, air traffic control centers, and emergency aircraft hangars.
      8) Water storage facilities and pump structures required to maintain water pressure for fire suppression.
      9) Buildings and other structures having critical national defense functions.
   b. Buildings and other structures (including, but not limited to, facilities that manufacturer, process, handle, store, use or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction.
   c. Component Importance Factor: As per ASCE, Section 9.6.
   d. Component Response Modification Factor: As per ASCE, Section 9.6.
   e. Component Amplification Factor: As per ASCE, Section 9.6.
7. Design Spectral Response Acceleration at Short Periods (0.2 Second): As per ASCE, Section 9.4.
8. Design Spectral Response Acceleration at 1-Second Period: As per ASCE, Section 9.4.

B. General Requirements:
   1. Install full line size flexible pipe connectors at the inlet and outlet of each piece of plumbing equipment and where shown on the drawings. All connections shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit elongation to 3/8 inch. Flexible connectors shall not be required for suspended in-line pumps.
   2. Unless otherwise specified, all plumbing equipment and pipe shall be restrained to resist seismic forces. Restraints shall maintain equipment, piping in a captive position.

Restriaint devices shall be designed and selected to meet the seismic requirements as defined in the latest issue of the IBC or local jurisdiction building code. Equipment importance factors are determined as follows:

a. $I_p = 1.5$ Life-safely component is required to function after an earthquake.
b. $I_p = 1.5$ Component contains hazardous or flammable material.
c. $I_p = 1.5$ Storage racks in occupancies open to the general public (e.g., warehouse retail stores).
d. $I_p = 1.0$ All other components.

C. Seismic Restraint Shall Not Be Required for the Following:

1. Rigidly floor mounted plumbing components in all seismic design categories, where I_p = 1.0 and flexible connections between the components and associated duct work, piping and conduit are provided, that are mounted at 4 feet or less above a floor level and weight 400 pounds or less and are not critical to the continued operation of the structure. Suspended, wall mounted and flexibly mounted equipment are not included in this exclusion.
2. Hanging wall mounted, and flexibly supported plumbing components that weigh 20 pounds or less where I_p = 1.0 and flexible connections are provided between the components and associate duct work, piping and conduit.
3. Piping supported by individual clevis hangers where the distance, as measured from the top of the pipe to the supporting structure, is less than 12 inches for the entire pipe run and the pipe can accommodate the expected deflections. Trapeze or double rod hangers where the distance from the top of the trapeze or support to the structure is less than 12 inches for the entire run. Hanger rods shall be constructed in a manner that would subject the rod to bending moments (swivel, eye bolt, or vibration isolation hanger connection to structure).
4. High deformability piping (steel copper, aluminum with welded, brazed, ground or screwed connections) designed as having an I_p = 1.5 and a nominal pipe size of 1 inch or less where provisions are made to protect the piping from impact or to avoid the impact of larger piping or other mechanical equipment. Note, any combination of piping supported on a trapeze where the total weight exceeds 10 pounds per foot must be braced.
5. High deformability piping (steel, copper, aluminum with welded, brazed, ground, or screwed connections) and limited deformability piping (cast iron, FRP, PVC) designated with an I_p = 1.0 and a nominal pipe size of 1-inch and less in the mechanical equipment room, of 2-inch and less outside the mechanical equipment room.
6. PVC or other plastic or fiberglass vent piping.

D. Manufacturer's Responsibilities:

1. Determine vibration isolation and seismic restraint size and locations.
2. Provide piping and equipment isolation systems and seismic restraints as scheduled or specified.
3. Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.
4. Provide calculations to determine restraint loads resulting from seismic forces presented in loan building code. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum 5 years' experience. Provide calculations for all floor or roof-mounted equipment 400 pounds or greater (20 pounds or greater for I_p = 1.5), all suspended or wall mounted equipment 20 pounds or greater, and vibration isolated equipment 20 pounds or greater.
5. Seismic restraint load ratings must be certified and substantiated by testing or calculations under direct control of a registered professional engineer.
6. Calculations and restraint device submittal drawings shall specify anchor bolt type embedment, concrete compressive strength, minimum spacing between anchors, and minimum distances of anchors from concrete edges. Concrete anchor locations shall not

be near edges, stress joints, or an existing fracture. All bolts shall be ASTM A307 or better.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.
2. 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 Submittal:
1. For each seismic-restraint device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, and concrete anchor and insert, that is required by this Section or is indicated on Drawings, submit the following:
   a. Seismic restraint, and vibration isolator, and isolation base selection: Select vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
   b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.
   c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
   d. Seismic Design Calculations: Submit all input data and loading calculations prepared in "Performance Requirements" Article in "Seismic Design Calculations" Paragraph.
   e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared in "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
   f. Licensed Professional Engineer: All designated-design submittals for seismic calculations are to be signed and sealed by licensed professional engineer responsible for their preparation.
2. Seismic-Restraint Detail Drawing:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
4. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by licensed professional engineer responsible for their preparation.

5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Welding certificates.

C. Field quality-control reports:

D. Seismic Certification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-16, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
1. Provide equipment manufacturer's written certification for each designated active plumbing seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270 (AHRI 1271), including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction, or experience data as permitted by ASCE/SEI 7-16.
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-16.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.
4. The following plumbing systems and components are Designated Seismic Systems and require written special certification of seismic certification by manufacturer:

E. Wind-Force Performance Certification: Provide special certification for plumbing components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
1. Provide equipment manufacturer's written certification for each designated plumbing device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
2. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.
3. The following plumbing systems and components require special certification for high wind performance. Written special certification of resistance to the effects of high wind force and impact damage must be provided by manufacturer:

1.5 QUALITY ASSURANCE

A. Testing Agency Certifications: An independent agency, with the experience and capability to conduct the testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Certifications: Procedures and personnel shall comply with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: An agency acceptable to authorities having jurisdiction.

D. Manufacturer must be a member of the Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

E. Steel components shall be cleaned and painted with industrial enamel. All nuts, bolts and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate of metal etching primer.

F. All isolators, bases and seismic restraints exposed to the weather shall utilize cadmium-plated, epoxy coat or PVC coated springs and hot dipped galvanized steel components. Nuts, bolts and washers may be zinc-electroplated. Isolators for outdoor mounted equipment shall provide adequate restraint for the greater of either wind loads required by local codes or withstand a minimum of 30 pounds per square foot applied to any exposed surface of the equipment.

G. Provide a written quality control procedure that outlines complete compliance of attachment of cabling restraints to brackets. For swaged connections, provide a gauge to verify swage. For screw/clamp connection, provide torque values for attachment fasteners.

PART 2 - PRODUCTS

2.1 RESTRAINTS - RIGID TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. CADDY; a brand of nVent.
   3. California Dynamics Corporation.
   4. Hilti, Inc.
   5. Isolation Technology, Inc.
   6. TOLCO.
   7. Unistrut; Part of Atkore International.
   8. Vibration Mountings & Controls, Inc.
   9. Vibro-Acoustics.

B. Description: Shop- or field-fabricated bracing assembly made of ANSI/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.

2.2 RESTRAINTS - CABLE TYPE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-Line, an Eaton business.
   2. CADDY; a brand of nVent.
   3. Loos & Co.

4. Vibration Mountings & Controls, Inc.
5. Vibro-Acoustics.

B. Seismic-Restraint Cables: ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic 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. 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.

2.3 RESTRAINT ACCESSORIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, and Eaton business.
2. CADDY; a brand of nVent.
3. Hilti, Inc.
4. Loos & Co.
5. Mason Industries, Inc.
6. TOLCO.
7. Unistrut; part of Atkore International.
8. Vibro-Acoustics.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

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.

2.4 POST-INSTALLED CONCRETE ANCHORS

A. Mechanical Anchor Bolts:
1. 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 required for anchor and as tested according to ASTM E488/E488M.

B. Provide post-installed concrete anchors that have been precertified for use in seismic applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-16, Ch. 13.
1. Precertify post-installed anchors in concrete in accordance with ACI 355.2 or other approved certification testing procedures.

2. Precertify post-installed anchors in masonry in accordance with approved certification procedures.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp, which is not vibration isolated.
1. Undercut expansion anchors are permitted.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

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 seismic forces.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and seismic load within specified loading limits.

3.2 INSTALLATION OF VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

D. Installation of vibration isolators and seismic restraints must not cause any stresses, misalignment, or change of position of equipment or piping.

E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

F. 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.

G. Install seismic-restraint cables so they do not bend across edges of adjacent equipment or building structure.

H. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

J. 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.

K. 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.

L. 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 Project 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. Mechanical-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.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic 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 221116 "Domestic Water Piping" and Section 221119 "Domestic Water Piping Specialties" for piping flexible connections.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a certified testing agency to perform tests and inspections.

B. Tests and Inspections:
   1. Perform tests and inspections with the assistance of a factory-authorized service representative.
   2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
5. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. Measure isolator restraint clearance.
8. Measure isolator deflection.
9. Verify snubber minimum clearances.
10. Test and adjust restrained-air-spring isolator controls and safeties.

C. Remove and replace malfunctioning units and retest as specified above.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Pipe labels.

1.2 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

PART 2 - PRODUCTS

2.1 IDENTIFICATION

A. Equipment and Pipe Identification:
   1. All plumbing systems shall be labeled.
      a. Equipment labels shall be 1/8-in thick plastic black face with white engraved lettering 3/16-in high or larger, and shall be attached securely.
         1) All labels associated with high temperature piping and in high temperature equipment room shall be as required in valve section below. No non-metal labels allowed.
      b. Equipment nameplates shall include the following minimum information:
         1) Plan identification.
         2) Capacity specified at designed operating conditions.
         3) Actual capacity as balanced at site operating conditions.
         4) Area or zone served.
      c. Valve tags shall be connected to valve stems by steel rings and include the following minimum information:
         1) Plan identification.
         2) Normal position.
         3) Duty.
         4) Area served.
         5) Valve type.
   2. All accessible piping shall be color coded and identified with working and arrows every 50 feet, at each riser, at each junction, at each access door, and where required to easily identify the medium transported.
   3. Piping systems shall be identified by:
      a. Background color.
      b. Lettering color.
      c. Flow direction arrow.
   4. Piping background color shall be applied to all exposed piping (either over bare pipe or the insulation) in mechanical rooms. Identifying lettering and arrows shall then be added as indicated above, and as necessary to be visible from anywhere in the room.

a. For chases, and other exposed areas, as well as piping routed in other exposed areas such as chases, background color shall be applied in a two foot (2'-0") wide band with identifying lettering and a flow direction arrow.
b. Background and lettering shall be semi-gloss enamel paint by DeVoe (Mirrolac), Pratt and Lambert, Glidden, Rust-Oleum, Sherwin Williams or prior approved equal. The colors specified herein shall not vary.

COLOR	SHERWIN WILLIAMS	PRATT & LAMBERT	RUST-OLEUM
Red	SW4081 Safety Red	1007 Vibrant Red	964 Federal Safety Red
Orange	SW4083 Safety Orange	S4507 Safety Orange	956 Federal Safety Orange
Yellow	SW4084 Safety Yellow	1732 Spectrum Yellow	944 Federal Safety Yellow
Green	SW4085 Safety Green	Safety Green	933 Federal Safety Green
Blue	SW4086 Safety Blue	1228 Anchors Aweigh	925 Federal Safety Blue
Purple	SW4080 Plum	Bright Medium	Bright Medium
Silver (Aluminum)	B59S11 Silver Brite	-	-
Black	Black	Effecto Black	634 Black
White	White	Effecto White	2766 White
Brown	SW4001 Bolt Brown	2278 Char Brown	-
University experience has shown that Mirrolac works well in this application, being durable with excellent coverage.			

c. Identifying lettering shall be painted or stenciled on pipe over the background color. Self-adhesive or glue-on type labels are acceptable. Letters shall be 2" high for duct and larger piping 3" or more, 1" high for 1-1/4" to 2-1/2" pipe, and 1/2" high for 1" pipe and smaller.
d. Arrows to indicate direction of flow shall be painted over the background color in the same color as the lettering. The arrow shall point away from the lettering. On duct and large piping 3" or more in diameter, the "shaft" of the arrow shall be 2" long and 1" wide. Smaller piping, 2-1/2" or less, shall have arrows with a shaft 1/2" wide and 2" long. Use a double-headed arrow if the flow can be in either direction.
e. Piping shall be identified with the following colors:

MEDIUM IN PIPE	BACKGROUND COLOR	IDENTIFYING LETTERING	LETTERING COLOR
COMPRESSED AIR			
Lab Service	Silver	Compressed Air	Black
Automatic Controls	Silver	Control Air	Black
COMPRESSED GAS			
Hydrogen	Brown	Nydrogen	Black
Natural Gas	Brown	Natural Gas	Yellow
Nitrogen	Silver	Nitrogen	Black
Oxygen	Brown	Oxygen	Black
VACUUM			
Vacuum	Silver	Vacuum	Black
WATER **NOTE: DIRECTIONAL ARROWS ARE REQUIRED ON HTW PIPING			
Cold Water (Potable)	Green	Domestic Cold Water	White
Non Potable	Green	Unsafe Water	Black
Domestic Hot Water (Potable)	Green	Domestic Hot Water	White
Domestic Hot Water Return	Green	Domestic How Water Return	White
Deionized	Green	Deionized Water	White
Distilled Water	Green	Distilled Water	White
Reverse Osmosis	Green	Rev. Osmosis Water	White
Softened	Green	Softened Water	Black

Roof Drain	Green	Roof Drain	White
System Make-Up	Green	Make-Up Water	White
Treated Water	Green	Treated Water	Black
WASTE			
Acid-Resistant	(unpainted)	Acid Waste	White
Building Waste	(unpainted) or Black	Waste	White
Polluted Water	Black	Polluted	Yellow
ALL EQUIPMENT OF PIPING LOCATED OUTSIDE BUILDINGS			
All Equipment or Piping Located Outside Buildings	Brown	---	---

2.2 PAINT, IDENTIFICATION

A. University approved vendor/manufacturer:
1. DeVoe Mirrolac
2. Pratt and Lambert
3. Glidden
4. Rust-Oleum
5. Sherwin Williams
6. For other products/manufacturers, prior approval is required.

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 EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

A. Permanently fasten labels on each item of plumbing equipment.

B. Locate equipment labels where accessible and visible.

3.4 INSTALLATION OF PIPE LABELS

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.

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.

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:
   1. Domestic and industrial cold-water piping.
   2. Domestic and industrial hot-water piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of insulation and jacket indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Material test reports.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Certifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. 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 and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "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.

1.6 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.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 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 shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come into contact with stainless steel shall 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 shall be certified as acceptable in accordance with ASTM C795.

E. Mineral-Fiber, Preformed Pipe: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Jones 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.
   3. 850 deg F.
   4. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
   5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

F. Insulation Covers, Fittings and Valves:
   1. University of Utah approved vendor/manufacturer:
      a. Zeston
      b. Sole source, no other products approved (standardized maintenance requirements).

G. Insulation Protection Inserts and Shields
   1. University of Utah approved vendor/manufacturer.
      a. Grinnell Fig. 167
      b. Similar/equal to (no prior approval required).

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber 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 Construction Products

C. ASJ 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 Construction Products
      c. Mon-Eco Industries, Inc.

D. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Dow Consumer Solutions.
      b. Johns Manville; a Berkshire Hathaway company
      c. P.I.C. Plastics, Inc.
      d. Speedline Corporation

2.3 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

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. Childers Brand; H. B. Fuller Construction Products.
      b. Foster Brand; H. B. Fuller Construction Products
      c. Knauf Insulation
      d. Vimasco Corporation.
   2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   3. Service Temperature Range: Minus 20 to plus 180 deg F.
   4. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
   5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   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 Construction Products
      c. Knauf Insulation
      d. Mon-Eco Industries, Inc.
      e. Vimasco Corporation
   2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
   3. Service Temperature Range: 0 to plus 180 deg F.
   4. Color: White.

2.4 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Metal Jacket Flashing 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 Construction Products

c. Mon-Eco Industries, Inc.
2. Materials shall be compatible with insulation material, jackets and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

C. ASJ Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Childers Brand; H. B Fuller Construction Products
2. Materials shall be compatible with insulation material, jackets and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.

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.

B. Insulation Facing:
1. University of Utah approved vendor/manufacturer:
a. Kraft FRK-25.
b. Sole source, no other products approved (standardized maintenance requirements)

2.6 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. Avery Dennison Corporation, Specialty Tapes Division
c. Ideal Tape Co., Inc., an American Biltrite Company
d. 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.

2.7 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 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.

3.2 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, soften, or otherwise attack insulation or jacket in either wet or dry state.

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. 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.

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.
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 more than 25 percent of its nominal thickness.

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.
4. Cleanouts.

3.3 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 078413 "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 078413 "Penetration Firestopping."

3.4 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.

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 fittings made from same material and density as that of adjacent pipe insulation. Each piece shall be 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 valves using preformed 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 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.

6. 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.
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 fabric-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.

D. Install removable insulation covers at locations indicated. Installation shall conform 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.

3.5 INSTALLATION OF MINERAL-FIBER 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 factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied 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 preformed 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 mineral-fiber 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 preformed 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 preformed sections of same material as that of straight segments of pipe insulation when available.
   2. When preformed sections are not available, install mitered 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.

3.6 FINISHES

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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.

3.7 FIELD QUALITY CONTROL

A. Owner will engage a certified testing agency to perform tests and inspections.

B. Engage a certified testing agency to perform tests and inspections.

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 shall be 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.

3.8 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. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.9 INDOOR PIPING INSULATION SCHEDULE

A. See Plans.

3.10 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:
   1. PVC: 20 mils thick.

END OF SECTION 220719

SECTION 220800 – COMMISSIONING OF PLUMBING SYSTEMS

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.
B. Section 019113 – General Commissioning Requirements

1.2 DEFINITION

A. Commissioning is a quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained as specified in the Owner's Project Requirements (OPR).

1.3 SCOPE

A. This Section shall form the basis of the construction phase commissioning process. The Commissioning Agent (CxA) shall add, modify, and refine the commissioning procedure to suit field conditions and manufacturers' equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks.
B. The following building systems are within the Commissioning Scope of Work:

1. Please review Sections 220800, 230800, and 260800.

1.4 QUALITY ASSURANCE

A. The commissioning process shall be conducted in accordance with the following reference documents.

1. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 202, Commissioning Process for Building and Systems
2. State of Utah – Department of Administrative Services Division of Facilities Construction and Management (DFCM) Design Requirements, High Performance Building Standards
3. National Environmental Balancing Bureau (NEBB) – Procedural Standards for Whole Building Systems Technical Commissioning
4. Building Commissioning Association (BCxA) – New Construction Building Commissioning Best Practice
5. AABC Commissioning Group Guidelines (ACG) – ACG Commissioning Guideline

1.5 COMMISSONED SYSTEMS

A. Commissioning shall be performed on the following systems and components.

1. Plumbing Fixtures
2. Domestic Water Piping
3. Drains & Cleanouts
4. Pressure Reducing Stations
5. Pre-Heat Coil Bank
6. Pumps
7. Glycol Make-Up Unit

PART 2: PRODUCTS (NOT APPLICABLE)

PART 3: EXECUTION

3.1 GENERAL

A. The Subcontractors shall be responsible for performing procedures presented in specification and contract drawings. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Documentation shall be dated and initialed by field engineer or technician performing the work. Final sign-off shall be by the Owner and Commissioning Agent.
B. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
C. Scope of Plumbing testing shall include entire Plumbing installation, for both cold water and hot water systems from service through distribution systems to all fixtures.
D. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors
E. The CxA in cooperation with the Plumbing Contractor, testing and balancing Contractor, and Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.
F. Tests will be performed using design conditions whenever possible.
G. Simulated conditions may need to be imposed when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
H. The CxA may direct that set points be altered when simulating conditions is not practical.
I. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
J. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.2 TEST INSTRUMENTATION

A. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Contractor
B. The test equipment shall be provided in sufficient quantities to execute functional testing in an expedient fashion.
C. The test equipment shall be suitable for testing and calibration with accuracy and tolerances necessary to demonstrate that system performance is in accordance with the basis of design.
D. Equipment used for functional testing sensors and gauges shall be certified to an accuracy of 10% of the smallest tolerance to be measured. For example, if a temperature gage is required to be ± 2°F, the calibration device must have a minimum accuracy of ± 0.2°F.
E. Instrumentation used for functional testing system performance must have a minimum repeatability and accuracy of ± 1.0% of the acceptance criteria being measured. For example, if a supply temperature of 50°F is being verified, the repeatability and accuracy of the test instrument must be at least ± 0.5°F.
F. The test equipment shall have calibration certification per equipment manufacturer's interval level or within one year if not specified.

3.3 PRE-FUNCTIONAL TESTING

A. Before system start-up begins, the Commissioning Team shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of work including change orders and punch list items to the Owner's satisfaction. The audit shall include, but not be limited to, checking of:

    1. Piping specialties including balance, control, and isolation valves.
    2. Control sensor types and location.

3. Identification of piping, valves, equipment, controls, etc.
4. Major equipment, pumps, valves, starters, gauges, thermometers, etc.
5. Documentation of pre-startup tests performed including manufacturer's factory tests.

B. The Subcontractor shall Review and Complete Prefunctional Checklists in accordance with Section 01 91 13 and 22 08 00
C. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
D. The CxA will verify that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
E. If work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up work proceeds.
F. The initial Prefunctional Checklists will be provided in the Commissioning Plan. The final checklists may be modifications of the initial checklists, and checklists may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
G. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work as specified in 01 91 13.
H. The Prefunctional Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere

3.4 STARTUP PLAN

A. The Contractor shall provide a Startup Plan, which shall include the following:

1. Prefunctional Checklists
2. Startup and testing procedures and data forms, in accordance with the project specifications, for all equipment and systems within the commissioning scope of work.
3. Piping testing reports, to be approved by the A/E.

   a. Flushing and cleaning of pipe.
   b. Filters, strainers, and screens.
   c. Valve positions.
   d. Electrical tests.
   e. Pressure tests.
   f. Safeties.

4. Water treatment reports to be approved by the A/E.
5. Manufacturer's tests.

B. Within 20 working days of Product Submittal approval, submit the Startup Plan with blank forms for CxA review.
C. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
D. Submit the completed Startup Plan prior to functional performance testing. When it is necessary to begin functional performance testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the Startup Plan that have been completed only for the system(s) that are ready for testing.
E. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a

significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to Section 01 91 13 General Commissioning Requirements for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

F. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.5 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
B. Notify the CxA at least 10 days in advance of testing and balancing work, and provide access for the CxA to witness testing and balancing work.
C. Provide technicians, instrumentation, and tools to verify testing and balancing of Plumbing systems at the direction of the CxA.

   1. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.
   2. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

D. The CxA will verify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

3.6 FUNCTIONAL PERFORMANCE TESTING

A. The Functional Performance Test (FPT) Procedures shall be developed, performed, and demonstrated in accordance with Section 01 91 13.
B. At a minimum, the plumbing contractor is required to participate in developing, performing, and demonstrating the indicated FPTs.
C. The initial FPTs shall be provided after review of the submittals. The final FPTs may be modifications of the initial FPTs, and FPTs may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
D. The Contractor’s Commissioning Coordinator shall coordinate the subcontractors, with the Commissioning Authority's input, in developing, performing, and demonstrating the FPTs.

END OF SECTION

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Copper tube and fittings.
   2. Piping joining materials.
   3. Transition fittings.
   4. Dielectric fittings.

B. Industrial hot & cold water piping shall be same as domestic water piping.

1.2 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. 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.

B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tube: ASTM B88, Type L.
   1. Joints:
      a. 95-5 Class SnSb solder.

B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

E. 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.

F. Wrought Copper Unions: ASME B16.22.

G. Copper Tube, Pressure-Seal-Joint Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. Elkhart Products Corporation.
c. Mueller Industries, Inc.
d. NIBCO INC.
e. Viega LLC.

2. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
3. Minimum 200-psig working-pressure rating at 250 deg F.

2.3 PIPING JOINING MATERIALS

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.

2.4 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.

2.5 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. A.Y. McDonald Mfg. Co.
b. Capitol Manufacturing Company
c. Central Plastics Company
d. HART Industrial Unions, LLC.
e. Jomar Valve.
f. WATTS.
g. Willkins.
h. Zurn Industries, LLC.

2. Standard: ASSE 1079.
3. Pressure Rating: 150 psig.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Capitol Manufacturing Company.
      b. Central Plastics Company.
      c. Matco-Norca.
      d. WATTS.
      e. Wilkins.
      f. Zurn Industries, LLC.
   2. Standard: ASSE 1079.
   3. Factory-fabricated, bolted, companion-flange assembly.
   4. Pressure Rating: 150 psig minimum at 180 Deg F.
   5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.
   2. Nonconducting materials for field assembly of companion flanges.
   3. Pressure Rating: 150 psig
   4. Gasket: Neoprene or phenolic.
   5. Bolt Sleeves: Phenolic or polyethylene.
   6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Elster Perfection Corporation.
      b. Grinnell G-Fire by Johnson Controls Company.
      c. Precision Plumbing Products.
      d. Sioux Chief Manufacturing Company, Inc.
      e. Victaulic Company.
   2. Standard: IAPMO PS 66.
   3. Electroplated steel nipple complying with ASTM F1545.
   4. Pressure Rating and Temperature: 300 psig at 225 deg F.
   5. End Connections: Male threaded or grooved.
   6. 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. Aboveground domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.

3.2 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 according to CDA's "Copper Tube Handbook."

C. Install domestic water piping level and plumb.

D. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

E. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

F. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

G. 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.

H. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

I. Install piping to permit valve servicing.

J. 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.

K. Install piping free of sags and bends.

L. Install fittings for changes in direction and branch connections.

M. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

P. Where indicated on the drawings, that the pipe will be exposed to direct UV light for more than 30 days, it shall be provided within factory applied, U-resistant coating or alternative UV protection.

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 pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to 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," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 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 and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.5 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

C. Install hangers for copper piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Support horizontal piping within 12 inches of each fitting.

E. Support vertical runs of copper tubing and piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 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.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
   3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection.

3.8 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 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.

3.10 FIELD QUALITY CONTROL

A. Perform the following 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 roughing in 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. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
      f. 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.

3.11 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 according to 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.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Vacuum breakers.

B. Industrial hot & cold piping specialties shall be same as domestic.

C. Related Requirements:
   1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for fire water-service backflow prevention devices.
   2. Section 220519 "Meters and Gauges for Plumbing Piping" for thermometers and pressure gauges in domestic water piping.

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.

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 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. High health hazard, anti-siphon, spill resistant backflow preventer (unit shall be re-buildable).
   1. Standard: ASSE 1056

2. Body: Bronze.
3. Inlet and Outlet Connections: Threaded.
4. Full port valves on inlet and outlet.
5. Spill resistant design.
6. Internal polymer coating.
7. Stainless steel spring.
8. Manufacturers;
   a. Watts 008PCQT
   b. Zurn 460XL

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.

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 FIELD QUALITY CONTROL

A. Testing Agency: Engage a certified testing agency to perform tests and inspections.

B. Prepare test and inspection reports.

END OF SECTION 221119

SECTION 226113 - COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Medical compressed-air piping, designated "medical air."
2. Gas-powered-tool compressed-air piping, designated "instrument air."
3. Shape-memory-metal couplings.
4. Pressure-seal fittings.
5. Flexible pipe connectors.
6. Zone valve box assemblies.
7. Ball valves.
8. Check valves.
9. Compressed-air safety valves.
10. Compressed-air service connections.

B. Related Requirements:
1. Section 115313 "Laboratory Fume Hoods" for compressed-air outlets in laboratory fume hoods.
2. Section 123553.13 "Metal Laboratory Casework" for compressed-air outlets in laboratory casework.
3. Section 123553.16 "Plastic-Laminate-Clad Laboratory Casework" for compressed-air outlets in laboratory casework.
4. Section 123553.19 "Wood Laboratory Casework" for compressed-air outlets in laboratory casework.
5. Section 123570 "Healthcare Casework" for compressed-air outlets in healthcare casework.
6. Section 221513 "General-Service Compressed-Air Piping" for general-service compressed-air piping and specialties.
7. Section 226119 "Compressed-Air Equipment for Laboratory and Healthcare Facilities" for air compressors and specialties.
8. Section 220963 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Certificates: For compressed-air manifolds, accessories, and components, from manufacturer.

B. Material Certificates: Signed by Installer, certifying that medical compressed-air piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

C. Brazing certificates.

D. Field Quality-Control Reports: Brazing certificates.

E. Source Quality Control Reports:
   1. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code, Section VIII.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Certifications:
   1. Medical Air Piping Systems for Healthcare Facilities: In accordance with ASSE Standard #6010 [**and**] [**NFPA 99**] for medical-gas-system installers.
   2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer in accordance with ASSE Standard #6040 [**and**] [**NFPA 99**].

B. Testing Agency Certifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is[**a member of the Medical Gas Professional Healthcare Organization or is**] an NRTL, and that is acceptable to authorities having jurisdiction.
   1. Certify testing personnel in accordance with ASSE Standard #6020 [**and**] [**NFPA 99**] for medical-gas-system inspectors and ASSE Standard #6030 [**and**] [**NFPA 99**] for medical-gas-system verifiers.

C. Brazing: Certified processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Medical air operating at 50 to 55 psig.

B. Instrument air operating at 175 psig.

C. Laboratory air operating at [**50 psig**] [**100 psig**] [**125 psig**].

D. All positive-pressure compressed-air products including piping, tubing, fittings, valves, zone valve boxes, manifolds, and service connections[**for systems serving patients in healthcare facilities**] are required to be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
   1. All are to be delivered plugged or capped by the manufacturer and are to be kept sealed until prepared for installation.

E. Seismic Performance: Compressed-air manifolds shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
   1. The term "withstand" means "the manifold will remain in place without separation of any parts when subjected to the seismic forces specified[**and the manifold will be fully operational after the seismic event**]."
   2. Component Importance Factor is [**1.5**] [**1.0**].

F. Comply with NFPA 99.

2.2 PIPES, TUBES, AND FITTINGS

A. Comply with ASME B31.1 for laboratory air piping operating at more than 150 psig.

B. Comply with ASME B31.9 for laboratory air piping operating at 150 psig or less.

C. Copper Medical Gas Tube: ASTM B819, [**Type K**] [**and**] [**Type L**], seamless, drawn temper. Include standard color marking "MED" or "OXY/MED" in green for Type K tube and in blue for Type L tube.

D. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.

E. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

F. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
   1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness, full-face type.
   2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.

G. Shape-Memory-Metal Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Aerofit, Inc.
      b. CAMERON; A Schlumber Co.
      c. Motion Industries
      d. Smart Tap; Smart Technology; Inc.
   2. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.

H. Copper Pressure-Seal Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Viega LLC
   2. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
   3. NPS 2-1/2 to NPS 4: Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.

I. Flexible Pipe Connectors:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Flex-Hose Co., Inc.
      b. Flexicraft Industries
      c. Hyspan Precision Products, Inc.
      d. Mercer Rubber Co.
      e. Metraflex Company (The).
      f. Proco Products, Inc.
      g. Universal Metal Hose.
   2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
      a. Working-Pressure Rating: [**200 psig**] [**250 psig**] minimum.
      b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gauges.
   1. Steel Zone-Valve Box with Aluminum Cover:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Amico Corporation
         2) BeaconMedaes
         3) CONCOA
         4) Ohio Medical Corporation
         5) Oxequip Health Industries; a division of Allied Healthcare Products Inc.
   2. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves.[**Medical air tubing, valves, and gauges may be incorporated in zone valve boxes for medical gases.**]
      a. Interior Finish: Factory-applied white enamel.
      b. Cover Plate: Aluminum with frangible or removable windows.
      c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.
   3. Steel Zone-Valve Box with Stainless Steel Cover:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Amico Corporation
         2) BeaconMedaes
         3) Ohio Medical Corporation
         4) Tri-Tech Medical
      b. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves.[**Medical air and medical vacuum tubing, valves, and gauges may be incorporated in zone valve boxes for medical gases.**]
      c. Interior Finish: Factory-applied white enamel.
      d. Cover Plate: Stainless steel with frangible or removable windows.
      e. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

C. Ball Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Amico Corporation
      b. Apollo Valves; a part of Aalberts Integrated Piping Systems
      c. BeaconMedaes
      d. Marwin Valve; Richards Industries.
      e. NIBCO INC.
      f. Ohio Medical Corporation
      g. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
      h. Tri-Tech Medical
   2. Standard: MSS SP-110.
   3. Description: Three-piece body, brass or bronze.

4. Pressure Rating: 300 psig minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever[**type with locking device**].
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: [**Manufacturer-installed ASTM B819, copper-tube extensions**] [**and**] [**manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension**].

D. Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amico Corporation
   b. Apollo Valves; a part of Aalberts Integrated Piping Systems
   c. BeaconMedaes.
   d. Marwin Valve; Richards Industries
   e. NIBCO INC.
   f. Ohio Medical Corporation
   g. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
   h. Tri-Tech Medical
2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig minimum.
4. Operation: Spring loaded.
5. Ends: Manufacturer-installed, ASTM B819, copper-tube extensions.

E. Compressed-Air Safety Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amico Corporation
   b. Apollo Valves; a part of Aalberts Integrated Piping Systems
   c. CEODEUX Meditec
   d. UCSF Health Environment of Care
2. Bronze body.
3. ASME-construction, poppet, pressure-relief type.
4. Settings to match system requirements.

F. Pressure Regulators:
1. Bronze body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
3. Manual pressure-setting adjustment.
4. Rated for 250-psig minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

2.5 MEDICAL COMPRESSED-AIR SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amico Corporation
2. BeaconMedaes
3. Ohio Medical Corporation
4. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
5. Tri-Tech Medical

B. General Requirements for Medical Compressed-Air Service Connections:

1. Suitable for specific medical air pressure and service listed.
2. Include roughing-in assemblies, finishing assemblies, and cover plates.
3. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent air leakage.
4. ASTM B819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:
1. Brass housing with primary check valve.
2. Double seals that will prevent air leakage.
3. Cover plate with gas-service label.

E. Quick-Coupler Pressure Service Connections:
1. Outlets for [**medical air**] [**and**] [**instrument air**] with noninterchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

F. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
1. Medical Air: D.I.S.S. No. 1160.
2. Instrument Air: D.I.S.S. No. 1160.

G. Cover Plates:
1. One piece.
2. [**Aluminum**] [**or**] [**stainless steel**].
3. Permanent, color-coded, identifying label matching corresponding service.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Air Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean medical air tube and fittings, valves, gauges, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service in accordance with CGA G-4.1.
2. Wash medical air tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
   a. Scrub to ensure complete cleaning.
   b. Rinse with clean, hot water to remove cleaning solution.

3.2 INSTALLATION OF PIPING

A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and

arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Comply with NFPA 99 for installation of compressed-air piping.

D. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

G. Install piping adjacent to equipment and specialties to allow service and maintenance.

H. Install piping with 1 percent slope downward in direction of flow.

I. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

J. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

K. Install branch connections to mains from top of main. Provide drain leg at end of each main and branch at low points.

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and for branch connections.

O. Install medical air piping to medical air service connections specified in this Section, to medical air service connections in equipment specified in Section 226313 "Gas Piping for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical air service.

P. Piping Restraint Installation: Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

Q. Install service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Connect piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

S. Install unions in copper tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 INSTALLATION OF VALVES

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on compressed-air piping where reduced pressure is required.

F. Install flexible pipe connectors in discharge piping[**and in inlet air piping from remote air-inlet filter**] of each air compressor.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of cleaned tubing and fittings before assembly.

C. Threaded Joints: Apply appropriate tape to external pipe threads.

D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.

E. Soldered Joints: Apply ASTM B813, water-flushable flux to tube end. Join copper tube and fittings in accordance with ASTM B828.

F. Extruded-Tee Outlets: Form branches in copper tube in accordance with ASTM F2014, with tools recommended by tube manufacturer.

G. Flanged Joints:
   1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.

H. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

3.5 INSTALLATION OF COMPRESSED-AIR SERVICE COMPONENTS

A. Install compressed-air pressure-control panel in walls. Attach to substrate.

B. Install compressed-air manifolds[**on concrete base**] anchored to substrate.

C. Install compressed-air cylinders and connect to manifold piping.

D. Install compressed-air manifolds with seismic restraints as indicated.

E. Install compressed-air-cylinder wall storage racks attached to substrate.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Vertical Piping: MSS Type 8 or Type 42 clamps.

C. Individual, Straight, Horizontal Piping Runs:
   1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
   2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

E. Base of Vertical Piping: MSS Type 52 spring hangers.

F. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 IDENTIFICATION

A. Install identifying labels and devices for laboratory compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical compressed-air piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   1. Medical Air: Black letters on yellow background.
   2. Instrument Air: White letters on red background.
   3. Laboratory Air: Black letters on yellow-and-white checkerboard background.

3.8 FIELD QUALITY CONTROL FOR MEDICAL COMPRESSED-AIR PIPING IN HEALTHCARE FACILITIES

A. Testing Agency:
   1. Owner will engage a certified testing agency to perform tests and inspections.
   2. Engage a certified testing agency to perform tests and inspections.

B. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].

C. Tests and Inspections:
   1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of [**medical gas piping**] [**and**] [**medical vacuum piping**] systems.
   2. Preparation: Perform the following Installer tests in accordance with requirements in NFPA 99 and ASSE Standard #6010:
      a. Initial blowdown.
      b. Initial pressure test.
      c. Cross-connection test.
      d. Piping purge test.
      e. Standing pressure test for positive-pressure medical compressed-air piping.
      f. Repair leaks and retest until no leaks exist.
   3. System Verification: Perform the following tests and inspections in accordance with NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
      a. Standing pressure test.
      b. [**Individual-pressurization**] [**or**] [**pressure-differential**] cross-connection test.
      c. Valve test.
      d. Master and area alarm tests.
      e. Piping purge test.
      f. Piping particulate test.
      g. Piping purity test.
      h. Final tie-in test.
      i. Operational pressure test.
      j. Medical air-purity test.
      k. Verify correct labeling of equipment and components.
   4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed, and certify report results. Include the following:
      a. Inspections performed.
      b. Procedures, materials, and gases used.
      c. Test methods used.
      d. Results of tests.

D. Prepare test and inspection reports.

3.9 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN LABORATORY FACILITIES

A. Testing Agency: [**Owner will engage**] [**Engage**] certified testing agency to perform tests and inspections of compressed-air piping in laboratory facilities and to prepare test and inspection reports.

B. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].

C. Tests and Inspections:
   1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.

D. Piping will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.11 PIPING SCHEDULE

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Flanges may be used where connection to flanged equipment is required.

C. Type L Copper Tubing for [**Medical Air Piping**] [**and**] [**Instrument Air Piping**], NPS 3 and Smaller, Operating between 15 psig and 50 psig: Type L copper tubing, wrought copper fittings, and brazed joints.

D. Type K Copper Tubing for [**Medical Air Piping**] [**and**] [**Instrument Air Piping**], NPS 3 and Smaller, Operating between 15 psig and 50 psig: Type K copper tubing, wrought copper fittings, and brazed joints.

E. Type L Copper Tubing for Laboratory Air Piping, NPS 3 and Smaller, Operating between 15 psig and 50 psig: Type L copper tubing, wrought copper fittings, and brazed joints.

3.12 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

END OF SECTION 226113

SECTION 226119 - COMPRESSED-AIR PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Lab air piping and specialties, operating at 50 to 55 psig.

1.2 SUBMITTALS

A. Product Data: For the following:
   1. Compressed-air valves.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Installer Requirements:
   1. Medical Compressed-Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.

B. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with NFPA 99, "Health Care Facilities," for medical compressed-air system materials and installation in healthcare facilities.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Types K and L, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.2 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.3 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Allied Healthcare Products, Inc.; Chemetron Div.
      b. Allied Healthcare Products, Inc.; Oxequip Health Industries.
      c. Amico Corporation.
      d. BeaconMedaes.
      e. Conbraco Industries, Inc.
      f. NIBCO INC.
      g. Squire-Cogswell/Aeros Instruments, Inc.
      h. Tri-Tech Medical.
   3. Pressure Rating: 300 psig minimum.
   4. Ball: Full-port, chrome-plated brass.
   5. Seats: PTFE or TFE.
   6. Handle: Lever.
   7. Stem: Blowout proof with PTFE or TFE seal.
   8. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

C. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.

D. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250 psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.

a. Scrub to ensure complete cleaning.
b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING APPLICATIONS

A. Lab Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.3 PIPING INSTALLATION

A. Comply with ASSE Standard #6010 for installation of compressed-air piping.

B. Install piping concealed from view and protected from physical contact by building occupants 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 and coordinate with other services occupying that space.

E. Install piping adjacent to equipment and specialties to allow service and maintenance.

F. Install air and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.

H. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

I. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

J. Install piping to permit valve servicing.

K. Install piping free of sags and bends.

L. Install fittings for changes in direction and branch connections.

M. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 VALVE INSTALLATION

A. Install shutoff valve where shown.

3.5 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel, clevis hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1/4: 60 inches with 3/8-inch rod.
   2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
   3. NPS 3/4: 84 inches with 3/8-inch rod.
   4. NPS 1: 96 inches with 3/8-inch rod.
   5. NPS 1-1/4: 108 inches with 3/8-inch rod.
   6. NPS 1-1/2: 10 feet with 3/8-inch rod.
   7. NPS 2: 11 feet with 3/8-inch rod.
   8. NPS 2-1/2: 13 feet with 1/2-inch rod.
   9. NPS 3: 14 feet with 1/2-inch rod.
   10. NPS 3-1/2: 15 feet with 1/2-inch rod.
   11. NPS 4: 16 feet with 1/2-inch rod.

J. Install supports for vertical copper tubing every 10 feet.

3.7 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   1. Lab Air: Black letters on yellow background.

3.8 FIELD QUALITY CONTROL FOR LAB COMPRESSED-AIR PIPING

A. Perform tests and inspections of lab compressed-air piping systems and prepare test reports.

B. Tests and Inspections:
   1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical vacuum piping systems.
   2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
      a. Initial blowdown.
      b. Initial pressure test.
      c. Cross-connection test.
      d. Piping purge test.
      e. Standing pressure test for positive-pressure medical compressed-air piping.
      f. Repair leaks and retest until no leaks exist.
   3. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
      a. Inspections performed.
      b. Procedures, materials, and gases used.
      c. Test methods used.
      d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

END OF SECTION 22 6119

SECTION 226213 - VACUUM PIPING FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Vacuum piping and specialties, designated "vacuum" operating at 20 inches mercury.

1.2 SUBMITTALS

A. Shop Drawings: Diagram power, signal, and control wiring.

B. Piping Material Certification: Signed by Installer certifying that medical vacuum piping materials comply with NFPA 99 requirements.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Installer Certifications:
   1. Medical Vacuum Piping Systems for Healthcare Facilities: Installers shall comply with ASSE Standard #6010.

B. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. NFPA Compliance: Comply with NFPA 99, "Health Care Facilities," for medical vacuum system materials and installation in healthcare facilities.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service.
   1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.

2.2 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

C. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.

D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

2.3 NITROGEN

A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
   2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
      a. Scrub to ensure complete cleaning.
      b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING APPLICATIONS

A. Vacuum Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.3 PIPING INSTALLATION

A. Comply with ASSE Standard #6010 for installation of vacuum piping.

B. Install piping concealed from view and protected from physical contact by building occupants 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 and coordinate with other services occupying that space.

E. Install piping adjacent to equipment and specialties to allow service and maintenance.

F. Install vacuum and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications below unless otherwise indicated.

H. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

I. Provide drain leg and drain trap at end of each main and branch and at low points.

J. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and for branch connections.

N. Install medical vacuum piping to medical vacuum service connections specified in this Section, to medical vacuum service connections in equipment specified in Division 22 Section "Gas Piping for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.

O. Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

P. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

Q. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

R. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

S. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

F. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.

G. Flanged Joints:
1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
2. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel, clevis hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: Support pipe rolls on trapeze. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches of each fitting and coupling.

G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1/4: 60 inches with 3/8-inch rod.
2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
3. NPS 3/4: 84 inches with 3/8-inch rod.
4. NPS 1: 96 inches with 3/8-inch rod.
5. NPS 1-1/4: 108 inches with 3/8-inch rod.
6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.
9. NPS 3: 14 feet with 1/2-inch rod.
10. NPS 3-1/2: 15 feet with 1/2-inch rod.
11. NPS 4: 16 feet with 1/2-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

J. Install supports for vertical PVC piping every 48 inches.

3.6 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for medical vacuum piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   1. Vacuum: Black letters on white background.

END OF SECTION 226213

SECTION 226600 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Single-wall piping.
   2. Piping specialties.

1.2 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.

1.3 SUBMITTALS

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

B. Field quality-control test reports.

C. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a certified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

1.5 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Neutralization-Tank Limestone: Equal to 200 percent of amount required for each tank sump initial charge. Furnish limestone in 50-lb bags.

PART 2 - PRODUCTS

2.1 SINGLE-WALL PIPE AND FITTINGS

A. PE Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ISCO Industries, LLC.
      b. Performance Pipe; a division of Chevron Phillips Chemical Company LLC.
      c. PolyPipe, Inc. Div.; Rinker Materials Corporation.
   2. Pipe: ASTM F 1412, Schedule 40.
   3. Fittings: ASTM F 1412, Schedule 40, socket-fusion, drainage pattern complying with ASTM D 3311.

B. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion- and mechanical-joint ends.
   1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. IPEX Inc.
      b. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
      c. Sloane, George Fischer Inc.
      d. Town & Country Plastics, Inc.
      e. Watts Industries (Canada) Inc.
      f. Zurn Plumbing Products Group; Chemical Drainage Systems.

2.2 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:
   1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
   2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
   3. Flanges may be used on aboveground piping unless otherwise indicated.
   4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
   5. 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.
   6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   7. Install piping at indicated slopes.
   8. Install piping free of sags and bends.
   9. Install fittings for changes in direction and branch connections.
   10. Verify final equipment locations for roughing-in.
   11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
   12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Chemical-Waste Piping Inside the Building:
   1. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
   2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
   3. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
   4. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.

3.3 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping.

B. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

C. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:
   1. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
   2. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
   3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   4. Base of Vertical Piping: MSS Type 52, spring hangers.

D. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical piping and tubing at base and at each floor.

G. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch.

H. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 2: 33 inches with 3/8-inch rod.
   2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6: 48 inches with 3/4-inch rod.

I. Install supports for vertical PP piping every 72 inches.

3.4 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.

C. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

D. Install piping adjacent to equipment to allow service and maintenance.

3.5 LABELING AND IDENTIFICATION

A. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
   1. Use warning tape or detectable warning tape over ferrous piping.
   2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.6 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.
   1. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Hydrostatic Tests for Drainage Piping:
         1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
         2) Close openings in system and fill with water.
         3) Purge air and refill with water.
         4) Disconnect water supply.
         5) Test and inspect joints for leaks.
      e. Air Tests for Drainage Piping: Comply with UNI-B-6.
   2. Leaks and loss in test pressure constitute defects that must be repaired.
   3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.7 ADJUSTING

A. Adjust leak-detection-system control and device settings.

3.8 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

3.9 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
1. NPS 1-1/2 to NPS 4: PE drainage pipe and fittings and heat-fusion joints.
2. NPS 1-1/2 to NPS 4: PP drainage pipe and fittings and electrofusion joints.

END OF SECTION 22 6600

SECTION 22 6700 - PROCESSED WATER SYSTEMS FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes deionized-water piping and distilled water piping.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure Ratings:
   1. Deionized-Water Piping: 100 psig unless otherwise indicated.

1.3 SUBMITTALS

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

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.3, "Process Piping," for piping conveying fluid at a pressure of 15 psig or greater.

PART 2 - PRODUCTS

2.1 PLASTIC PIPE AND FITTINGS

A. PP Pipe and Fittings for Heat-Fusion Joints: Made from ASTM D 4101, PP resin.
   1. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

B. PP Pipe and Fittings for Electro-Fusion Joints: Made from ASTM D 4101, PP resin.
   1. George Fischer LLC
   2. Schedule 80, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 80 dimensions; with socket fittings matching pipe dimensions.
   3. Electro-Fusion Fitting: Electrical-resistance heating coil for PP piping joints.

C. PVDF Pipe and Fittings: Made from ASTM D 3222, PVDF resin.
      a. Asahi/America.
      b. George Fischer LLC.
      c. NIBCO INC.
      d. Orion Fittings; a division of Watts Water Technologies Inc.
   2. Schedule 40, Pipe and Fittings: Pipe made to ASTM D 2447, Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

2.2 TRANSITION FITTINGS

A. Transition Fittings: Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 PP VALVES

A. PP Ball Valves:
   1. Description:
      a. Standard: MSS SP-122.
      b. Pressure Rating: 150 psig.
      c. Body Material: ASTM D 4101, PP resin.
      d. Body Design: Union type.
      e. End Connections: Detachable, butt or socket.
      f. Ball: ASTM D 4101, PP resin.
      g. Port: Full.
      h. Seats: PTFE.
      i. Stem: ASTM D 4101, PP resin.
      j. Stem Seals: FKM-rubber O-rings.
      k. Handle: Tee shaped.

2.4 PVDF VALVES

A. PVDF Ball Valves:
   1. Description:
      a. Standard: MSS SP-122.
      b. Pressure Rating: 150 psig.
      c. Body Material: ASTM D 3222, PVDF resin.
      d. Body Design: Union type.
      e. End Connections: Detachable, butt or socket.
      f. Ball: ASTM D 3222, PVDF resin.
      g. Port: Full.
      h. Seats: PTFE.
      i. Stem: ASTM D 3222, PVDF resin.
      j. Stem Seals: FKM-rubber O-rings.
      k. Handle: Tee shaped.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for removal of ceiling panel, and coordinate with other services occupying that space.

F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

G. Install piping to permit valve servicing.

H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. PP Piping Electro-Fusion Joints: Make according to ASTM F 1290.

C. PP Piping Heat-Fusion Joints: Make according to ASTM D 2657.

D. PVDF Piping Heat-Fusion Joints: Make according to ASTM D 2657.

E. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 VALVE INSTALLATION

A. Install sectional valves close to mains on each branch and riser serving equipment.

B. Install shutoff valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.

E. Install plastic valves of the same material as the plastic pipe in which they are installed.

F. Install valves in horizontal piping with stem at or above center of pipe.

G. Install valves in position to allow full movement of stem and lever handle.

H. Install ball-check valves in horizontal or vertical position so ball will unseat during normal flow.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Division 15 Section "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
   3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
   5. Clamps for Vertical Piping: MSS Type 8 or Type 42.
   6. Individual, Straight, Horizontal Piping Runs:
      a. 100 Feet and Less: MSS Type 1, adjustable clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   7. Multiple, Straight, Horizontal Piping Runs, 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, to minimum 3/8 inch.

F. Install padded hangers for PP piping with the following maximum horizontal spacing and minimum rod diameter: 32 inches with 3/8-inch rod.

G. Install padded supports for vertical PP piping at midstory for NPS 2 and smaller.

H. Install padded hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameter: 30 inches with 3/8-inch rod.

I. Install padded supports for vertical PVDF piping at midstory for NPS 2 and smaller.

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect deionized-water piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

A. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. Test new piping, and parts of existing piping that have been altered, extended, or repaired, for leaks and defects.
   1. Schedule tests and their inspections by authorities having jurisdiction, with at least 24 hours' advance notice.
   2. Do not cover piping or put into service before inspection and approval.
   3. Test completed piping according to authorities having jurisdiction. If authorities having jurisdiction do not have published procedures, perform tests as follows:
      a. Hydrostatic Tests: Test piping at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 100 psig.
   4. Replace leaking joints with new materials and retest until no leaks exist.
   5. Submit separate reports for each test.

3.8 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
   1. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
   2. Clean piping by flushing with system deionized water.

3.9 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.

B. Deionized-Water Piping: Use any of the following piping materials for each pipe size range:
   1. PP pipe and fittings and heat-fusion joints.
   2. PP pipe and fittings and electro-fusion joints.
   3. PVDF pipe and fittings and heat-fusion joints.

3.10 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
   1. Shutoff Duty: Install ball valves in piping NPS 2 and smaller.
   2. Throttling Duty: Install ball valves in piping NPS 2 and smaller.

END OF SECTION 22 6700

TABLE OF CONTENTS

DIVISION 23 – HVAC

23 0500	COMMON WORK RESULTS FOR HVAC
23 0513	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 0548	VIBRATION AND SEISMIC CONTROLS FOR HVAC
23 0553	IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 0593	TESTING, ADJUSTING AND BALANCING FOR HVAC
23 0713	DUCT INSULATION
23 0800	COMMISSIOING OF HVAC SYSTEMS
23 0900	INSTRUMENTATION AND CONTROL FOR HVAC
23 0991	FUME HOOD CONTROLS
23 1123	FACILITY NATURAL GAS PIPING
23 3113	METAL DUCTS
23 3300	AIR DUCT ACCESSORIES
23 3423	HVAC POWER VENTILATORS
23 3600	AIR TERMINAL UNITS
23 3713.13	AIR DIFFUSERS
23 3713.23	REGISTERS AND GRILLES

END OF TABLE OF CONTENTS

SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:
1. Submittals.
2. Quality Assurance.
3. Examination.
4. Preparation.
5. Repair/Restoration.
6. Cleaning.
7. Piping Installation.
8. Dielectric fittings.
9. Mechanical sleeve seals.
10. Sleeves.
11. Escutcheons.
12. Grout.
13. HVAC demolition.
14. Equipment installation requirements common to equipment sections.
15. Supports and anchorages.
16. Operation and Maintenance Manuals.

1.2 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 SUBMITTALS

A. Welding certificates.

B. Product Data:
1. Manufacturer’s catalog data for each manufactured item.
   a. Provide section in submittal for each type of item of equipment. Include Manufacturer’s catalog data of each manufactured item and enough information to show compliance with Contract Document requirements. Literature shall show capacities and size of equipment used and be marked indicating each specific item with applicable data underlined.
   b. Include name, address, and phone number of each supplier.

C. Shop Drawings:
   1. Schematic control diagrams for each separate fan system, heating system, control panel, etc. Each diagram shall show locations of all control and operational components and devices. Mark correct operating settings for each control device on these diagrams.
   2. Diagram for electrical control system showing wiring of related electrical control items such as firestats, fuses, interlocks, electrical switches, and relays. Include drawings showing electrical power requirements and connection locations.
   3. Drawing of each temperature control panel identifying components in panels and their function.
      a. Other shop drawings required by Division 23 trade Sections.

1.4 QUALITY ASSURANCE

A. Steel Support Welding: Processes and operators shall comply with AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Processes and operators shall comply with to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS certification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
   1. The contractor shall verify motor voltages with the electrical drawings before ordering motorized equipment and controls. Motor name plate voltage shall be NEMA standard 200 volt for 208 volt three phase system and shall be NEMA. Standard 230 volt for 240 volt three phase or single phase system. Starter heaters installed shall be coordinated with the name plate data.

D. Requirements of Regulatory Agencies:
   1. Perform work in accordance with applicable provisions of Plumbing Codes and Gas Ordinances applicable to Project. Provide materials and labor necessary to comply with rules, regulations and ordinances.
   2. In case of differences between building codes, laws, local ordinances, utility company regulations, and Contract Documents, the most stringent shall govern. Notify Architect in writing of such differences before performing work affected by such differences.

E. Identification:
   1. Motor and equipment name plates as well as applicable UL and AGA labels shall be in place when Product is turned over to Owner.
   2. Materials shall bear Manufacturer’s name and trade name. Equipment and materials of same general type shall be of same make throughout work to provide uniform appearance, operation, and maintenance.

1.5 OPERATION AND MAINTENANCE DATA

A. Summary:
   1. This Section includes administrative and procedure requirements for preparing operation and maintenance manuals, including the following:
      a. Operation manuals for systems, subsystems, and equipment.
      b. Maintenance manuals for the care and maintenance of products, materials, finishes, systems and equipment.

B. Submittals:
   1. Manual: Submit one copy of each manual in final form at least 15 days before final inspection. Architect will return copy with comments within 15 days after final inspection.
      a. Correct or modify each manual to comply with Architect's comments. Submit 3 copies of each corrected manual within 15 days of receipt of Architect's comments.

PART 2 - PRODUCTS

2.1 EXAMINATION:

A. Site Inspection:
   1. Examine premises to understand conditions that may affect performance of work of this Division before submitting proposals for this work. Examine adjoining work on which mechanical work is dependent for efficiency and report work that requires correction.
   2. No subsequent allowance for time or money will be considered for any consequence related to failure to examine site conditions.

B. Drawings:
   1. Plumbing and Mechanical Drawings show general arrangement of piping, ductwork, equipment, etc. Follow as closely as actual building construction and work of other trades will permit.
   2. Consider Architectural and Structural Drawings part of this work insofar as these drawings furnish information relating to design and construction of building. These drawings take precedence over Plumbing and Mechanical Drawings.
   3. Because of scale of Drawings, it is not possible to indicate all offsets, fittings, and accessories that may be required. Investigate structural and finish conditions affecting this work and arrange work accordingly, providing such fittings, valves, and accessories required to meet conditions.

C. Ensure that items to be furnished fit space available. Make necessary field measurements to ascertain space requirements including those for connections and furnish and install equipment of size and shape so final installation shall suit true intent and meaning of Contract Documents. If approval is received by Addendum or Change Order to use other than originally specified items, be responsible for specified capacities and for ensuring that items to be furnished will fit space available.

2.2 PREPARATION:

A. Check that slots and openings provided under other Divisions through floors, walls, ceilings, and roofs are properly located. Perform cutting and patching caused by neglecting to coordinate with Divisions providing slots and openings at no additional cost to Owner.

B. Changes Due to Equipment Selection:
   1. Where equipment specified or otherwise approved requires different arrangement or connections from that shown in Contract Documents, submit drawings, if requested by Architect, showing proposed installations.
   2. If proposed changes are approved, install equipment to operate properly and in harmony with intent of Contract Documents. Make incidental changes in piping, ductwork, supports, installation, wiring, heaters, panelboards, and as otherwise necessary.
   3. Provide any additional motors, valves, controllers, fittings, and other additional equipment required for proper operation of the system resulting from selection of equipment, including all required changes in affected trades.
   4. Be responsible for the proper location of roughing-in and connections provided under other Divisions.

2.3 REPAIR/RESTORATION:

A. Each Section of this Division shall bear expense of cutting, patching, repairing, and replacing of work of other Sections required because of its fault, error, tardiness, or because of damage done by it.
   1. Patch and repair walls, floors, ceilings, and roofs with materials of same quality and appearance as adjacent surfaces unless otherwise shown.
   2. Surface finishes shall exactly match existing finishes of same materials.

B. Cutting, patching, repairing, and replacing pavements, sidewalks, roads, and curbs to permit installation of work of this Division is responsibility of Section installing work.

2.4 CLEANING:

A. Clean exposed piping, ductwork, equipment, and fixtures. Remove stickers from fixtures and adjust flush valves.

B. No more than one week before Final Inspection, flush out bearings and clean other lubricated surfaces with flushing oil. Provide best quality and grade of lubricant specified by Equipment Manufacturer.

C. Replace filters in equipment for moving air with new filters of specified type no more than one week before Final Inspection.

2.5 PIPING INSTALLATION:

A. Interface With Other Work:
   1. Furnish sleeves, inserts, supports, and equipment that are to be installed by others in sufficient time to be incorporated into construction as work proceeds. Locate these items and see they are properly installed.

B. Furnish and install complete system of piping, valved as indicated or as necessary to completely control entire apparatus.
   1. Pipe drawings are diagrammatic and indicate general location and connections. Piping may have to be offset, lowered, or raised as required or directed at site. This does not relieve this Division from responsibility for proper erection of systems of piping in every respect.
   2. Arrange piping to not interfere with removal of other equipment, ducts, or devices, or block access to doors, windows, or access openings.
      a. Arrange so as to facilitate removal of tube bundles.
      b. Provide accessible flanges or ground joint unions, as applicable for type of piping specified, at connections to equipment and on bypasses.
         1) Make connections of dissimilar metals with di-electric unions.
         2) Install valves and unions ahead of traps and strainers. Provide unions on both sides of traps.
      c. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running traps.
      d. Do not use reducing bushings, street elbows, bull head tees, close nipples, or running couplings.
      e. Install piping systems so they may be easily drained. Provide drain valves at low points and manual air vents at high points in hot water heating and cooling water piping.
      f. Install piping to insure noiseless circulation.
      g. Place valves and specialties to permit easy operation and access. Valves shall be regulated, packed, and glands adjusted at completion of work before final acceptance.

3. Do not install piping in shear walls.

C. Properly support piping and make adequate provisions for expansion, contraction, slope and anchorage.
1. Cut piping accurately for fabrication to measurements established at site. Remove burr and cutting slag from pipes.
2. Work piping into place without springing or forcing. Make piping connections to pumps and other equipment without strain at piping connection. Remove bolts in flanged connections or disconnect piping to demonstrate that piping has been so connected, if requested.
3. Make changes in direction with proper fittings.
4. Except for underground pipe, suspend piping from roof trusses or clamp to vertical walls using Unistrut and clamps. Do not hang pipe from other pipe, equipment, or ductwork. Laying of piping on any building element is not allowed.
5. Supports for Horizontal Piping:
   a. Support metal piping at 96 inches mm on center maximum for pipe 1-1/4 inches or larger and 72 inches on center maximum for pipe 1-1/8 inch or less.
   b. Support thermoplastic pipe at 48 inches on center maximum.
   c. Provide support at each elbow. Install additional support as required.
6. Supports for Vertical Piping:
   a. Place riser clamps at each floor or ceiling level.
   b. Securely support clamps by structural members, which in turn are supported directly from building structure.
   c. Provide clamps as necessary to brace pipe to wall.
7. Insulate hangers for copper pipe from piping by means of at least two layers of Scott 33 plastic tape.
8. Expansion of Thermoplastic Pipe:
   a. Provide for expansion in every 30 feet of straight run.
   b. Provide 12 inch offset below roof line in each vent line penetrating roof.

D. Provide sleeves around pipes passing through concrete or masonry floors, walls, partitions, or structural members. Do not place sleeves around soil, waste, vent, or roof drain lines passing through concrete floors on grade. Seal sleeves with specified sealants.
1. Sleeves through floors shall extend 1/4 inch above floor finish in mechanical equipment rooms above basement floor. In other rooms, sleeves shall be flush with floor.
2. Sleeves through floors and foundation walls shall be watertight.

E. Provide spring clamp plates (escutcheons) where pipes run through walls, floors, or ceilings and are exposed in finished locations of building. Plates shall be chrome plated heavy brass of plain pattern and shall be set tight on pipe and to building surface.

2.6 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.7 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series or BAg1, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12.

G. Solvent Cements for Joining Plastic Piping:
   1. CPVC Piping: ASTM F 493.
   2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.8 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.9 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

C. Pressure Plates: Carbon steel. Include two for each sealing element.

D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.10 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.11 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

2.12 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   2. Design Mix: 5000-psi, 28-day compressive strength.
   3. Packaging: Premixed and factory packaged.

2.13 OPERATION AND MAINTENANCE MANUALS

A. General:
   1. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain a title page, table of contents, and manual contents.
   2. Title Page: Enclose title page in transparent plastic sleeve. Include the following information.
      a. Subject matter included in manual.
      b. Name and address of Project.
      c. Name and address of Owner.
      d. Date of submittal.
      e. Name, address, and telephone number of Contractor.
      f. Name and address of Architect.
      g. Cross-reference to related systems in other operation and maintenance manuals.
   3. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
   4. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
      a. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2 by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

1) Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.

b. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.

c. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.

d. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

1) If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.

2) If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

5. Include copies of approved shop drawings and copies of warranties required in individual Sections of Division 23.

B. Operation Manuals

1. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and equipment descriptions, operating standards, operating procedures, operating logs, wiring and control diagrams, and license requirements.

2. Descriptions: Include the following:

a. Product name and model number.

b. Manufacturer's name.

c. Equipment identification with serial number of each component.

d. Equipment function.

e. Operating characteristics.

f. Limiting conditions.

g. Performance curves.

h. Engineering data and tests.

i. Complete nomenclature and number of replacement parts.

3. Operation Procedures: Include start-up, break-in, and control procedures; stopping and normal shutdown instructions; routine, normal, seasonal, and weekend operating instructions; and required sequences for electric or electronic systems.

4. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

5. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

C. Product Maintenance Manual

1. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

2. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.

3. Product Information: Include the following, as applicable:

a. Product name and model number.

b. Manufacturer's name.

c. Color, pattern, and texture.

d. Material and chemical composition.

e. Reordering information for specially manufactured products.

4. Maintenance Procedures: Include manufacturer's written recommendations and inspection procedures, types of cleaning agents, methods of cleaning, schedule for cleaning and maintenance, and repair instructions.
5. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
6. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

D. Systems and Equipment Maintenance Manual
1. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturer's maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
2. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
3. Manufacturer's Maintenance Documentation: Manufacturer's maintenance documentation including maintenance instructions, drawings and diagrams for maintenance, nomenclature of parts and components, and recommended spare parts for each component part or piece of equipment.
4. Maintenance Procedures: Include test and inspection instructions, troubleshooting guide, disassembly instructions, and adjusting instructions, and demonstration and training videotape if available, that detail essential maintenance procedures.
5. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
6. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
7. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
8. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
5. Equipment to Be Removed: Disconnect and cap services and remove equipment.

6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

D. Building owner shall have first right of refusal for any equipment or material that is to be removed.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to 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 unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.7 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.8 O & M MANUAL PREPREPARATION

A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material and finish incorporated into the Work.

B. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.

C. Manufacturer’s Data: Where manuals contain manufacturer’s standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each

product or component incorporated into the Work. If data includes more than one item in a tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

D. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.
   1. Do not use original Project Record Documents as part of operation and maintenance manuals.

E. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 230500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 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 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty Design B at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. 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.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1, 12-12 NEMA premium efficient.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Strator: Random-wound, squirrel cage, induction design.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Motor overall class shall be F with class H inverter duty insulated wire.

I. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 180T and larger; rolled steel for motor frame sizes smaller than 140T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. 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.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient 1700 V spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and NEMA Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1.31 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   1. Permanent-split capacitor.
   2. Split phase.
   3. Capacitor start, inductor run.
   4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. 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 shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Includes But Not Limited To:
   1. Requirements for anchorage and seismic restraint systems and vibration isolation systems for HVAC equipment.

B. Related Requirements:
   1. Furnishing and installing of seismic restraint and vibration isolation systems is by installer of equipment requiring such systems.
      a. Manufacturers of equipment specified to receive seismic restraint shall provide product data needed for calculation of seismic restraint needs. This information shall include, but not be limited to, equipment dimensions, dimensioned anchor points, operating weight, and center of gravity.

C. 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.

D. Related Requirements:
   1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
   2. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:
   1. Basic Wind Speed: As per AHJ.
   2. Building Classification Category as defined in ASCE 7-10 Table 1.5.1: III.
   3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in ASCE.

a. Where the soil properties are not known in sufficient detail to determine the site class. Site Class D shell be used unless the authority having jurisdiction or geotechnical data determine Site Class E or F soils are present at the site.

2. Assigned seismic Use Group or Building Category as Defined in the IBC: **[I]** **[II]** **[III]** **[IV]**.
3. Risk Category 1:
   a. Buildings and other structures that represent a low risk to human life in the event of failure.
4. Risk Category II:
   a. All buildings and other structures except those listed in Risk Categories I, III, and IV.
5. Risk Category III:
   a. Buildings and other structures , the failure of which could pose a substantial risk to human life.
   b. Buildings and other structures not included in Risk Category IV with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure.
   c. Buildings and other structures not included in Risk Category IV (including but, not limited to, facilities that manufacture, process, handle, store, use or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where their quantity exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
6. Risk Category IV:
   a. Buildings and other structures designated at essential facilities.
   b. Buildings and other structures, the failure of which could pose a substantial hazard to the community.
   c. Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) continuing sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released.
   d. Buildings and other structures required to maintain the functionality of other Risk Category IV Structures.
   e. Component Importance Factor (I_p) as defined in ASCE 7-10 Chapter 13, Section 13.1.3. 1.0.
   f. Component Response Modification Factor (R_p) as defined in ASCE, Section 7-10, Table 13.6.1.
   g. Component Amplification Factor (A_p) as defined in ASCE 7-10, Table 13.6.1.
   h. 0.2 sec Spectral Response Acceleration 5% of Critical Damping, Site Class B, (S_s) as defined in ASCE 7-10, Chapter 22.
   i. 1 sec Design Spectral Response Acceleration, 5 % of Critical Damping, Site Class B, (S1) as defined in ASCE 7-10, Chapter 22.

C. General Requirements:
1. Install full line size flexible pipe connectors at the inlet and outlet of each pump, cooling tower, condenser, chiller, cooling connections and where shown on the drawings. All connectors shall be suitable for use at the temperature, pressure, and service encountered at the point of installation and operation. End fitting connectors shall conform to the pipefitting schedule. Control rods or protective braid must be used to limit elongated to 3/8 inch. Flexible connectors shall not be required for suspended in-line pumps.
2. Unless otherwise specified, all mechanical equipment, pipe, and duct shall be restrained to resist seismic forces. Restraints shall maintain equipment, piping and duct work in a captive position. Restraint devices shall be designed and selected to meet the seismic

requirements as defined in the 2018 Edition of the International Building Code, ASCE 7-10 and local jurisdiction building code. Equipment importance factors are determined as follows:

a. The Component Importance Factor (I_p) shall be taken as 1.0 unless the Component Importance Factor (I_p) must be taken as 1.5
b. The Component Importance Factor (I_p) shall be taken as 1.5 if:
   1) The component is required to function for the life-safety purposes after an earthquake.
   2) The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction and is sufficient to pose a threat to the public if released.
   3) The component is in or attached to a Risk Category IV structure and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.
   4) The component conveys, supports, or otherwise contains hazardous substances and is attached to a structure or portion thereof classified by the authority having jurisdiction as a hazardous occupancy.

3. Components that are installed in-line with the duct system and have an operating weight greater than 75 lbs. such as fans, heat exchangers, and humidifiers, shall be supported and laterally braced independent of the duct system.
4. Appurtenances such as dampers, louvers, and diffusers shall be positively attached with mechanical fasteners.
5. Unbraced piping attached to in-line equipment shall be provided with adequate flexibility to accommodate the seismic relative displacements.
6. Piping that is not ASME pressure piping or NFPA 13 fire protection sprinkler piping, and mechanical components with hazardous substances that are assigned a component importance factor, I_p of 1.5 shall be designed including consideration of service loads based on the following allowable stresses:
   a. For piping constructed with ductile materials (e.g., steel, aluminum, or copper), 90 percent of the minimum specified yield strength.
   b. For threaded connections in piping constructed with ductile materials. 10 percent of the material minimum specified tensile strength.
   c. For piping constructed with nonductile materials (e.g., cast iron or ceramics), 10 percent of the material minimum specified tensile strength.
   d. For threaded connections in piping constructed with nonductile materials 8 percent of the material minimum specified tensile strength.
7. Piping not detailed to accommodate the seismic relative displacements at connections to other components shall be provided with connections having sufficient flexibility to avoid failure of the connection between the components.

D. Seismic Resistant Shall Not Be Required for the Following:
1. Temporary or moveable equipment.
2. Mechanical and electrical components in Seismic Design Category A and B.
3. Mechanical components in Seismic Design Category C provided that the Component Importance Factor (I_p) is equal to 1.0.
4. Mechanical components in Seismic Design Categories D, E, or F where all of the following apply:
   a. The component importance factor (I_p) is equal to 1.0.
   b. The component is positively attached to the structure.
   c. Flexible connections are provided between the component and associated ductwork, piping and conduit and either:
      1) The component weighs 400 lbs or less and has a center of mass located 4 ft. or less above the adjacent floor level or

2) The component weighs 20 lbs or less or, in the case of a distributed system 5 lb/ft. or less.

5. HVAC ductwork, not designed to carry toxic, or flammable gases or used for smoke control where either –
   a. Trapeze assemblies are used to support ductwork and the total weight of the ductwork supported by trapeze assemblies is less than 10 lb/ft or
   b. The ductwork is supported by hangers and each hanger in the duct run is 12 inch, or less in length from the duct support point to the supporting structure. Where rod hangers are used, they shall be equipped with swivels to prevent in elastic bending in the rod.
6. HVAC ductwork, not designed to carry toxic, highly toxic, or flammable gases or used for smoke control where provisions are made to avoid impact with larger ducts or mechanical components or to protect the ducts in the event of such impact and HVAC ducts have a cross-sectional area of less than 6 ft^2 or weigh 17 lb/ft or less.
7. Piping supported by trapeze assemblies where the total weight of the pipe on the trapeze is less than 10 lb/ft and no single pipe is larger than:
   a. 2" nominal pipe size in Seismic Design Category A, B, or C and I_p equal 1.0 or 1.5.
   b. 1" nominal pipe size in Seismic Design Category A, B, C, D, E or F and I_p equals 1.0 or 1.5.
   c. 3" nominal pipe size in Seismic Design Category A, B, C, D, E, or F and I_p equals 1.0.
8. The piping is supported by individual hangers or trapeze assemblies and each hanger in the piping run is 12 inch or less in length from the top of the pipe or supported trapeze to the supporting structure. Where rod hangers are used, they shall be equipped with swivels, eye nuts, or other devices to prevent bending in the rod.
9. Piping having an R_p of 4.5 or greater is used and provisions are made to avoid impact with other structural or nonstructural components or to protect the piping in the event of such impact and the pipe is not larger than:
   a. 2" nominal pipe size in Seismic Design Category A, B, or C and I_p equals 1.0 or 1.5.
   b. 1" nominal pipe size in Seismic Design Category A, B, C, D, E, or F and I_p equals 1.0 or 1.5.
   c. 3" nominal pipe size in Seismic Design Category A, B, C, D, E, or F and I_p equals 1.0.

E. Special Certification of Designated Seismic Systems:
   1. Active mechanical equipment with a Component Importance Factor (I_p) of 1.5 and in Seismic Design Category C, D, E or F shall be certified by the manufacturer exclusively on the basis of approved shake table testing in accordance with ASCE 7-10 Section 13.2.5 or experience data in accordance with ASCE 7-10 Section 13.2.6.

F. Special Certification of Designated Seismic Systems shall not be required for:
   1. Inactive mechanical equipment with no parts, critical to the function of the equipment, that rotate, move mechanically, or are engaged during operation, such as pipes and ducts.
   2. Rugged mechanical equipment such as:
      a. Mechanical equipment that contains an electric motor less than or equal to hp or heat transfer capacity less than or equal to 200 MBH.
      b. Valves (not in cast iron housing, except for ductile cast iron).
      c. Pneumatic operators.
      d. Hydraulic operations.
      e. Horizontal and vertical pumps.
      f. Chiller, factory packaged unit.
      g. Air compressors.
      h. Refrigerators and freezers.

G. Manufacturer's Responsibilities:
   1. Determine vibration isolation and seismic restraint sizes and locations.
   2. Provide piping, ductwork, and equipment isolation systems and seismic restraints as scheduled or specified.
   3. Provide installation instructions and shop drawings for all materials supplied under this section of the specifications.
   4. Provide calculations to determine restraint loads resulting from seismic forces required by the 2018 IBC and ASCE 7-10.
      a. Seismic calculations shall be certified by a licensed engineer in the employ of the seismic equipment manufacturer with a minimum of 5 years of experience.
   5. Provide seismic calculations for all vibration isolated floor or roof-mounted equipment 400 pounds or greater (20 pounds or greater I_p = 1.5), all suspended or wall mounted equipment 20 pounds or greater, and vibration isolated equipment 20 pounds or greater.
   6. Seismic restraint load ratings must be listed by ICC-ES (International Code Conference Evaluation Service), UL (Underwriters Laboratories) or other nationally recognized independent third party listing service that is acceptable to the authority having jurisdiction.
   7. Calculations and restraint device submittal drawings shall specify their anchorage to the structure:
      a. Concrete anchors shall be seismically prequalified in accordance with ACI 355.2.
      b. Concrete anchor calculations shall be based on ICC-ES Reports and calculated in accordance with ACI 318-14 Chapter 17.
      c. Concrete anchor calculations shall include:
         1) Concrete compressive strength and slab thickness.
         2) Concrete anchor diameter, nominal embedment depth and edge distance.
         3) Consideration of the effects of prying and eccentricities.
         4) Consideration of the seismic load effect over strength factor per ASCE 7-10 Supplement 1.
         5) All bolts shall be ASTM A307 or better.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Detail fabrication and assembly of equipment bases.
   2. 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 Submittal:
   1. For each seismic-restraint and wind-load protection device, including seismic-restrained mounting, pipe-riser resilient support, snubber, seismic restraint, seismic-restraint accessory, concrete anchor and insert, and restrained isolation roof-curb rail that is required by this Section or is indicated on Drawings, submit the following:
      a. Seismic and Wind-Load Restraint, and Vibration Isolation Base Selection: Select vibration isolators, seismic and wind-load restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data.
      b. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification by professional engineer that riser system was examined for excessive stress and that none exists.

c. Concrete Anchors and Inserts: Include calculations showing anticipated seismic and wind loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
d. Seismic Design Calculations: Submit all input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
e. Wind-Load Design Calculations: Submit all static and dynamic loading calculations prepared under "Wind-Load Design Calculations" Paragraph in "Performance Requirements" Article.
f. Licensed Professional Engineer: All designated-design submittals for seismic- and wind-restraint calculations are to be signed and sealed by licensed professional engineer responsible for their preparation.

2. Seismic-and Wind-Restraint Detail Drawing:
   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply also with requirements in other Sections for equipment mounted outdoors.
3. All delegated-design submittals for seismic- and wind-restraint detail Drawings are to be signed and sealed by licensed professional engineer responsible for their preparation.
4. Product Listing, Preapproval, and Evaluation Documentation: By an evaluation service member of ICC-ES, showing maximum ratings of restraint items and basis for approval (tests or calculations).
5. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
6. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Welding certificates.

C. Field quality-control reports.

D. Submit shop drawings of all isolators, seismic restraints and calculations provided.

E. The manufacturer of vibration isolation products shall submit the following data for each piece of isolated equipment.
   1. Clearly identified equipment tag, quantity and size of vibration isolators and seismic restraints for each piece of rotating isolated equipment.
   2. Submittals for mountings and hangers incorporating springs shall include spring diameter and free height, rated deflections, and solid load.

3. Submittals for bases shall clearly identify locations for all mountings as well as all locations for attachment points of the equipment to the mounting base.
4. Submittals shall include seismic calculations signed and checked by a licensed engineer.
5. Catalog cut sheets and installation instructions shall be included for each type of isolation mounting or seismic restraint used on equipment being isolated.

F. Submit quality assurance procedures as required under paragraph 1.5 at time of isolator/seismic submittals. Submittal must be stamped by a registered professional engineer who is responsible for the seismic restraint design. All vibration isolation/seismic submittals not complying with this certification will be rejected.

G. Provide shop drawings indicating location of all cable restraints required for pipe and ductwork. Drawings must be stamped by manufacturer's registered professional engineer.

H. Manufacturers of designated seismic system mechanical equipment that is required to have Special Certification in accordance with paragraph 1.2 E shall provide certification that their equipment is capable of resisting expected seismic loads without failure. These equipment manufacturers shall provide suitable attachment points and/or instructions for attaching seismic restraints.

I. Provide a certification from the seismic design engineer that the seismic restraints will comply with the applicable code requirements. Certification must be stamped by a registered professional engineer.

J. Provide a Certification of Completion from the manufacturer's representative upon completion of the job.

K. Seismic Certification Data: Provide special certification for designated seismic systems as indicated in ASCE/SEI 7-10, Paragraph 13.2.2, "Special Certification Requirements for Designated Seismic Systems" for all Designated Seismic Systems identified as such on Drawings or in the Specifications.
1. Provide equipment manufacturer's written certification for each designated active mechanical seismic device and system, stating that it will remain operable following the design earthquake. Certification must be based on requirements of ASCE/SEI 7 and AHRI 1270, including shake table testing per ICC-ES AC156 or a similar nationally recognized testing standard procedure acceptable to authorities having jurisdiction ASCE/SEI 7-10.
2. Provide equipment manufacturer's written certification that components with hazardous contents maintain containment following the design earthquake by methods required in ASCE/SEI 7-10.
3. Submit evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by a licensed professional engineer.

L. Wind-Force Performance Certification: Provide special certification for HVAC components subject to high wind exposure and impact damage and designated on Drawings or in the Specifications to require wind-force performance certification.
1. Provide equipment manufacturer's written certification for each designated HVAC device, stating that it will remain in place and operable following the design wind event and comply with all requirements of authorities having jurisdiction.
2. Provide manufacturer's written certification for each designated louver, damper, or similar device, stating that it will remain in place and protect opening from penetration of windborne debris and comply with all requirements of authorities having jurisdiction.
3. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

1.5 QUALITY ASSURANCE

A. Testing Agency Certifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7, and be acceptable to authorities having jurisdiction.

B. Welding Certifications: Personnel shall comply with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic- and Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: An evaluation service member of ICC-ES.

D. Steel components shall be cleaned and painted with industrial enamel. All nuts, bolts, and washers shall be zinc-electroplated. Structural steel bases shall be thoroughly cleaned of welding slag and primed with zinc-chromate or metal etching primer.

E. All isolators, bases and seismic restraints exposed to the weather shall utilize cadmium-plated epoxy coat or PVC coated springs and hot dipped galvanized steel components. Nuts, bolts and washers may be zinc-electroplated. Isolators for outdoor mounted equipment shall provide adequate restraint for the greater of either wind loads required by local codes or withstand a minimum of 30 pounds per square foot applied to any exposed surface of the equipment.

F. Provide a written quality control procedure that outlines complete compliance of attachment of cabling restraints to brackets. For swaged connections, provide a gage to verify swage. The use of “U” shaped cable clips and wedge type fittings is prohibited. Only swaged and poured socket connections comply with ASCE 19-10.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a licensed professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic and wind-load control system.
   1. Seismic and Wind-Load Performance: Equipment shall withstand the effects of earthquake motions and high wind events determined in accordance with ASCE/SEI 7-10.

B. Consequential Damage: Provide additional seismic restraints for suspended HVAC components or anchorage of floor-, roof-, or wall-mounted HVAC components as indicated in ASCE/SEI 7-10 so that failure of a non-essential or essential HVAC component will not cause failure of any other essential architectural, mechanical, or electrical building component.

C. Fire/Smoke Resistance: Seismic- and wind-load-restraint devices 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.

D. 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. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-10 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation.
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, Inc.
   m. Vibro-Acoustics.
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. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
   a. Surface Pattern: Smooth, ribbed, or waffle pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation.
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, Inc.
   m. Vibro-Acoustics.
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. Elastomeric Material: Molded, oil- and water-resistant neoprene rubber, silicone rubber, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation.
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, Inc.
   m. Vibro-Acoustics.
2. Description: All-directional isolator with seismic 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.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Controls, Inc.
   f. Korfund.
   g. Mason Industries, In.
   h. Novia; A Division of C&P.
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation.
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, 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 psig.

7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Vibration Eliminator Co., Inc.
   i. Vibration Management Corp.
   j. Vibration Mountings & Controls, Inc.
   k. Vibro-Acoustics.
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. 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 psig.
   b. Top housing with attachment and leveling bolt.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Novia; A Division of C&P
   i. Vibration Eliminator Co., Inc.
   j. Vibration Isolation
   k. Vibration Management Corp.
   l. Vibration Mountings & Controls, Inc.
   m. Vibro-Acoustics.
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 psig.
   b. Top plate with threaded mounting holes, elastomeric pad.
   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.

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, provide products by one of the following:
   a. Ace Mountings Co., Inc.
   b. CADDY; a brand of nVent.
   c. California Dynamics Corporation
   d. Isolation Technology, Inc.
   e. Kinetics Noise Control, Inc.
   f. Korfund.
   g. Mason Industries, Inc.
   h. Vibration Eliminator Co., Inc.
   i. Vibration Isolation.
   j. Vibration Management Corp.
   k. Vibration Mountings & Controls, Inc.
   l. Vibro-Acoustics.
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 psig.
   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.

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, provide products by one of the following:
   a. California Dynamics Corporation
   b. Kinetics Noise Control, Inc.
   c. Mason Industries, Inc.
   d. Vibration Eliminator Co., Inc.
   e. Vibration Management Corp.
2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
3. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

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, provide products by one of the following:
      a. California Dynamics Corporation
      b. Kinetics Noise Control, Inc.
      c. Mason Industries, Inc.
      d. Vibration Eliminator Co., Inc.
      e. Vibration Management Corp.
      f. Vibration Mountings & Controls, 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, provide products by one of the following:
      a. Ace Mountings Co., Inc.
      b. CADDY; a brand of nVent.
      c. California Dynamics Corporation
      d. Kinetics Noise Control, Inc.
      e. Mason Industries, Inc.
      f. Novia; A Division of C&P.
      g. Vibration Eliminator Co., Inc.
      h. Vibration Isolation.
      i. Vibration Management Corp.
      j. Vibration Mountings & Controls, Inc.
      k. Vibro-Acoustics.
   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.

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, provide products by one of the following:
      a. Ace Mountings Co., Inc.
      b. CADDY; a brand of nVent.
      c. California Dynamics Corporation
      d. Kinetics Noise Control, Inc.
      e. Mason Industries, Inc.
      f. Novia: A Division of C&P.
      g. Vibration Eliminator Co., Inc.
      h. Vibration Isolation.
      i. Vibration Management Corp.
      j. Vibration Mountings & Controls, Inc.
      k. Vibro-Acoustics.

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. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
9. 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, provide products by one of the following:
1. CADDY; a brand of nVent.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Vibration Management Corp.
5. Vibration Mountings & Controls, Inc.
6. Vibro-Acoustics.

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 seismically certified 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: Seismically certified 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, provide products by one of the following:
1. B-line, an Eaton business.
2. CADDY; a brand of nVent.
3. California Dynamics Corporation
4. Hilti, Inc.
5. Isolation Technology, Inc.
6. TOLCO
7. Unistrut; Part of Atkore International
8. Vibration Mountings & Controls, Inc.
9. Vibro-Acoustics.

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, provide products by one of the following:
   1. B-line, an Eaton business.
   2. CADDY; a brand of nVent.
   3. Loos & Co.
   4. Vibration Mountings & Controls, Inc.
   5. Vibro-Acoustics.

B. Seismic-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 seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket or mechanical (Flemish eye) loop.

C. Restraint cable assembly with cable fittings must comply with ASCE/SEI 19. 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, provide products by one of the following:
   1. B-line, an Eaton business.
   2. CADDY; a brand of nVent.
   3. Hilti, Inc.
   4. Loos & Co.
   5. Mason Industries, Inc.
   6. TOLCO
   7. Unistrut; Part of Atkore International
   8. Vibro-Acoustics.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

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. 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. Provide post-installed concrete anchors that have been certified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-10, Ch. 13.
   1. Precertify post-installed anchors in concrete in accordance with ACI 355.2 or other approved certification testing procedures.
   2. Precertify post-installed anchors in masonry in accordance with approved certifications procedures.

C. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
   1. Undercut expansion anchors are permitted.

2.18 CONCRETE INSERTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. B-line, an Eaton business.
   2. Hilti, Inc.
   3. Mason Industries, Inc.
   4. Powers Fasteners
   5. Simpson Strong-Tie Co., Inc.
   6. Unistrut Part of Atkore International.

B. Provide preset concrete inserts that are seismically precertified in accordance with ICC-ES AC466 testing.

C. Comply with ANSI/MSS SP-58.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static, wind load, and seismic loads within specified loading limits.

3.2 INSTALLATION OF VIBRATION-CONTROL, WIND-LOAD CONTROL, AND SEISMIC-RESTRAINT DEVICES

A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Devices Schedules, where indicated on Drawings, or where Specifications indicate they are to be installed on specific equipment and systems.

B. Provide seismic-restraint and wind-load control devices for systems and equipment where indicated in Equipment Schedules or Seismic-Restraint Devices Schedules, where indicated on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.

C. Installation of vibration isolators, wind-load restraints, must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

E. Equipment Restraints:
   1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
   2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   3. Install seismic-restraint, and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

F. 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.

G. Install seismic- and wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.

H. Install seismic- and wind-load-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

J. 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.

K. 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.

L. Mechanical Anchor Bolts:
   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. Set anchors to manufacturer's recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Provide flexible connections in piping systems where they cross structural seismic 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 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for piping flexible connections.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a certified testing agency to perform tests and inspections.

B. Tests and Inspections:
1. Perform tests and inspections with the assistance of a factory-authorized service representative.
2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
6. Test to 90 percent of rated proof load of device.
7. Measure isolator restraint clearance.
8. Measure isolator deflection.
9. Verify snubber minimum clearances.
10. Test and adjust restrained-air-spring isolator controls and safeties.

C. Remove and replace malfunctioning units and retest as specified above.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Equipment labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

PART 2 - PRODUCTS

2.1 IDENTIFICATION

A. Equipment, Pipe and Duct Identification:
   1. All heating, air conditioning, automatic temperature control equipment (excluding thermostats and relays), and distribution systems shall be labeled.
      a. Equipment labels shall be 1/8-in thick plastic black face with white engraved lettering 3/16-in high or larger, and shall be attached securely.
         1) All labels associated with high temperature piping and in high temperature equipment room shall be as required in valve section below. No non-metal labels allowed.
      b. Equipment nameplates shall include the following minimum information:
         1) Plan identification.
         2) Capacity specified at designed operating conditions.
         3) Actual capacity as balanced at site operating conditions.
         4) Area or zone served.
      c. Valve tags shall be connected to valve stems by steel rings and include the following minimum information:
         1) Plan identification.
         2) Normal position.
         3) Duty.
         4) Area served.
         5) Valve type.
      d. Additionally, heating water valves, steam valves, and all valves located in the secondary (low pressure) side of HTW heat exchangers shall include the manufacturer, size, grade and pressure-temperature service rating.
   2. All accessible duct and piping shall be color coded and identified with working and arrows every 50 feet, at each riser, at each junction, at each access door, and where required to easily identify the medium transported.
   3. Duct and piping systems shall be identified by:
      a. Background color.
      b. Lettering color.
      c. Flow direction arrow.

4. Duct and piping background color shall be applied to all exposed piping (either over bare pipe or the insulation) in mechanical rooms. Identifying lettering and arrows shall then be added as indicated above, and as necessary to be visible from anywhere in the room.
   a. For duct in mechanical rooms, chases, and other exposed areas, as well as piping routed in other exposed areas such as chases, background color shall be applied in a two foot (2'-0") wide band with identifying lettering and a flow direction arrow.
   b. Background and lettering shall be semi-gloss enamel paint. The colors specified herein shall not vary.

COLOR	SHERWIN WILLIAMS	PRATT & LAMBERT	RUST-OLEUM
Red	SW4081 Safety Red	1007 Vibrant Red	964 Federal Safety Red
Orange	SW4083 Safety Orange	S4507 Safety Orange	956 Federal Safety Orange
Yellow	SW4084 Safety Yellow	1732 Spectrum Yellow	944 Federal Safety Yellow
Green	SW4085 Safety Green	Safety Green	933 Federal Safety Green
Blue	SW4086 Safety Blue	1228 Anchors Aweigh	925 Federal Safety Blue
Purple	SW4080 Plum	Bright Medium	Bright Medium
Silver (Aluminum)	B59S11 Silver Brite	-	-
Black	Black	Effecto Black	634 Black
White	White	Effecto White	2766 White
Brown	SW4001 Bolt Brown	2278 Char Brown	-
University experience has shown that Mirrolac works well in this application, being durable with excellent coverage.			

   c. Identifying lettering shall be painted or stenciled on duct or pipe over the background color. Self-adhesive or glue-on type labels are acceptable. Letters shall be 2" high for duct and larger piping 3" or more, 1" high for 1-1/4" to 2-1/2" pipe, and 1/2" high for 1" pipe and smaller.
   d. Arrows to indicate direction of flow shall be painted over the background color in the same color as the lettering. The arrow shall point away from the lettering. On duct and large piping 3" or more in diameter, the "shaft" of the arrow shall be 2" long and 1" wide. Smaller piping, 2-1/2" or less, shall have arrows with a shaft 1/2" wide and 2" long. Use a double-headed arrow if the flow can be in either direction.
   e. Piping and duct shall be identified with the following colors:

MEDIUM IN PIPE OR DUCT	BACKGROUND COLOR	IDENTIFYING LETTERING	LETTERING COLOR
REFRIGERANT			
Freon	Black	Freon	White
STEAM – LOW PRESSURE (0 – 15 PSIG) (NOTE: NO BANDS FOR LOW PRESSURE)			
Steam - Low Pressure	Orange	Low-Press. Steam	Black
STEAM – HIGH PRESSURE (OVER 15 PSIG) (NOTE: TWO BLACK BANDS REQUIRED FOR HIGH PRESSURE)			
Steam – High Pressure	Orange	Hi-Press. Steam	White
WATER **NOTE: DIRECTIONAL ARROWS ARE REQUIRED ON HTW PIPING			
Boiler Blow-Off	Yellow	Blow-Off Water	Black
Chilled Water Supply	Blue	Chilled Water Supply	White
Chilled Water Supply	Blue	Chilled Water Return	White
Condenser Water Supply	Blue	Cooling Water Supply	White
Condenser Water Return	Blue	Cooling Water Return	Black
Condensate Return (Note: One white band is required for Steam Condensate Return.)	Orange	Condensate Return	Black
Glycol Solution	Purple	Glycol Solutions	White

High Temperature Supply	Yellow **	High Temperature Water Supply	Black
High Temperature Return	Yellow **	High Temperature Wager Return	Black
Secondary Heating Water Supply	Brown	Heating Water Supply	White
Secondary Heating Water Return	Brown	Heating Water Return	White
ALL EQUIPMENT OF PIPING LOCATED OUTSIDE BUILDINGS			
All Equipment or Piping Located Outside Buildings	Brown	---	---

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.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Testing, Adjusting, and Balancing of Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Testing, adjusting, and balancing of equipment.
   3. Testing, adjusting, and balancing of existing HVAC systems and equipment.
   4. Procedures for exhaust hoods.
   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. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting certifications to perform TAB work.

F. TDH: Total dynamic head.

G. UFAD: Underfloor air distribution.

1.3 INFORMATIONAL SUBMITTALS

A. Certification 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 certifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.

C. Strategies and Procedures Plan: Within 15 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 30 days of Contractor's Notice to Proceed, submit system readiness checklists, as specified in "Preparation" Article.

E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

F. Certified TAB reports.

G. Sample report forms.

H. 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.

1.4 QUALITY ASSURANCE

A. TAB Specialists Certifications, Certified by AABC:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
   2. TAB Technician: Employee of the TAB specialist and certified by AABC.

B. TAB Specialists Certifications, Certified by NEBB or AABC:
   1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or AABC.
   2. TAB Technician: Employee of the TAB specialist and certified by NEBB or AABC.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

F. Acceptable Test and Balance Companies:
   1. BTC Services
   2. Bonneville Test and Balance
   3. R.S. Analysis

1.5 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. 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 Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

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. Verify

that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.

F. Examine equipment performance data, including fan and pump curves.
   1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.

L. Examine heat-transfer coils and for clean and straight fins.

M. Examine operating safety interlocks and controls on HVAC equipment.

N. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.

O. 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.

3.2 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. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
2. Duct systems are complete with terminals installed.
3. Volume, smoke, and fire dampers are open and functional.
4. Clean filters are installed.
5. Fans are operating, free of vibration, and rotating in correct direction.
6. Variable-frequency controllers' startup is complete and safeties are verified.
7. Automatic temperature-control systems are operational.
8. Ceilings are installed.
9. Windows and doors are installed.
10. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance" 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. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, 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. Fan Systems: Include labor and material for one (1) pulley and belt change per fan system.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' Record drawings duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

3.5 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.
      c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   2. Measure fan static pressures as follows:
      a. Measure static pressure directly at the fan outlet or through the flexible connection.
      b. Measure static pressure directly at the fan inlet or through the flexible connection.
      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.
   3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
   4. 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.
   5. 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 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.
   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. Readjust to design 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. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 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. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow, so that connected total matches fan selection and simulates actual load in the building.
   c. 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.
   d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
6. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.

c. Measure static pressure across each component that makes up the air-handling system.
d. Report any 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.

3.7 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. Starter size and thermal-protection-element rating.
   8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 PROCEDURES FOR EXHAUST HOODS

A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.

B. Makeup Air: Systems supplying source of makeup air to hoods shall be in operation during testing and balancing of exhaust hoods.
   1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
   2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.

C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.

D. Laboratory Fume Hoods: Measure and record the following:
   1. Pressure drop across hood.

2. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity. If hood is connected to exhaust duct distribution through an exhaust device with integral airflow measurement, that reading may be used in lieu of a duct traverse.
3. Face velocity across open hood face and calculate hood airflow.
   a. Clearly indicate the direction of flow at each point of measurement.
   b. Measure velocity across opening on not less than 6-inch centers. Record velocity at each measurement, and calculate average velocity.
4. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
5. ASHRAE 110 Testing: With room and laboratory fume hood operating at design conditions, perform an "as-installed" performance test of the laboratory fume hood in accordance with ASHRAE 110. Test each laboratory fume hood and document the test results.

E. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.9 DUCT LEAKAGE TESTS

A. Witness the duct leakage testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified limits.

C. Report deficiencies observed.

3.10 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.

3.11 HVAC CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:
   1. Verify HVAC control system is operating within the design limitations.
   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.

3.12 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 refrigerant charge.
   5. Check the condition of filters.
   6. Check the condition of coils.
   7. Check the operation of the drain pan and condensate-drain trap.
   8. Check bearings and other lubricated parts for proper lubrication.
   9. 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. Bearings and other parts are properly lubricated.
   6. 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. If calculations increase or decrease the airflow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   4. Balance each air outlet.

3.13 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, within 10 cfm.
   2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
   3. Condenser-Water Flow Rate: Plus 10 percent or minus 5 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.14 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 monthly 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.

3.15 FINAL 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. Fan curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. 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.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name 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 fans 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. Fan drive settings, including settings and percentage of maximum pitch diameter.
f. Variable-frequency controller settings for variable-air-volume systems.
g. Settings for pressure controller(s).
h. 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. Duct, outlet, and inlet sizes.
3. Terminal units.
4. Balancing stations.
5. Position of balancing devices.

E. 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.

F. 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.

G. 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.

H. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.16 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

B. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall 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 shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.

E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
1. TAB specialists shall 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 shall be tracked to show changes made to previous report.
2. If the second final inspection also fails, Design Professional may pursue others Contract options to complete TAB work.

F. Prepare test and inspection reports.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

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

1.2 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct Insulation Schedule," and "Aboveground, Outdoor Duct Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. CertainTeed Corporation.
      b. Johns Manville; a Berkshire Hathaway company.
      c. Knauf Insulation.
      d. Manson Insulation Inc.
      e. Owens Corning

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber 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. Eagle Bridges – Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Mon-Eco Industries, Inc.

C. ASJ 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. Eagle Bridges – Marathon Industries.
      c. Foster Brand; H. B. Fuller Construction Products.
      d. Mon-Eco Industries, Inc.

2.3 SEALANTS

A. ASJ Flashing Sealants:
   1. Manufacturers: Subject to compliance with requirements, provide products by the following:
      a. Childers Brand; H. B. Fuller Construction Products.
   2. Materials shall be compatible with insulation materials, jackets, and substrates.
   3. Fire- and water-resistant, flexible, elastomeric sealant.
   4. Service Temperature Range: Minus 40 to plus 250 deg F.
   5. Color: White.

2.4 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.

2.5 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. Avery Dennison Corporation, Specialty Tapes Division.
      b. Compac Corporation.
      c. Ideal Tape Co., Inc., an American Biltrite Company.
      d. Knauf Insulation.
      e. Venture Tape.
   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.

B. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Avery Dennison Corporation, Specialty Tapes Division.
b. Compac Corporation.
c. Ideal Tape Co., Inc., an American Biltrite Company.
d. Knauf Insulation.
e. Venture Tape.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.6 SECUREMENTS

A. Aluminum Bands: 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.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. ITW Insulation Systems; Illinois Tool Works, Inc.
b. RPR Products, Inc.

B. Insulation Pins and Hangers:
1. 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:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) AGM Industries, Inc.
2) Gemco.
3) Hardcast, Inc.
4) Midwest Fasteners, Inc.
5) Nelson Stud Welding.
b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. 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:
a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1) Gemco
2) Midwest Fasteners, Inc.
b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.

c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. 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:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Hardcast, Inc.
      4) Midwest Fasteners. Inc.
   b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
   d. Adhesive-backed base with a peel-off protective cover.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) AGM Industries, Inc.
      2) Gemco.
      3) Hardcast, Inc.
      4) Midwest Fasteners, Inc.
      5) Nelson Stud Welding.
   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Gemco.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

2.7 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 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, soften, or otherwise attack insulation or jacket in either wet or dry state.

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.

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.
   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 more than 75 percent of its nominal thickness.

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.

3.3 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 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

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 078413 "Penetration Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts: 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 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 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 shall 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 shall 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.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. 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.

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.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 DUCT INSULATION SCHEDULE

A. See Drawings.

END OF SECTION 230713

SECTION 230800 – COMMISSIONING OF HVAC SYSTEMS

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.
B. Section 019113 – General Commissioning Requirements

1.2 DEFINITION

A. Commissioning is a quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained as specified in the Owner's Project Requirements (OPR). The Commissioning Authority shall provide the Owner with an unbiased, objective view of the systems installation, operation, and performance. This process is not to take away or reduce the responsibility of the design professionals or installing contractors to provide a finished product. Commissioning is intended to enhance the quality of system start-up and aid in the orderly transfer of systems to beneficial use by the owner. The Commissioning Authority will be a member of the construction team, cooperating and coordinating all commissioning activities with the design professionals, construction manager, contractors, subcontractors, manufacturers and equipment suppliers.

1.3 SCOPE

A. This Section shall form the basis of the construction phase commissioning process. The Commissioning Agent (CxA) shall add, modify, and refine the commissioning procedure to suit field conditions and manufacturers' equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks.

B. Participants in HVAC Systems Commissioning: HVAC systems shall be conducted with representatives from the following entities (the required participants shall be confirmed with the commissioning agent prior to scheduling the commissioning).

   a. General Contractor
   b. Mechanical Contractor
   c. BMS or ATC Contractor
   d. Factory Authorized Service Personnel for all major pieces of equipment. This is not a sales representative, but an authorized technician certified to work on the piece of equipment.
   e. Water Treatment Contractor
   f. The Electrical Contractor
   g. Test and Balance Contractor
   h. Owners Representative

C. Kickoff, Coordination and MEP Meetings

   a. Weekly meetings shall be held by the CxA with full participation and attendance of all participants as indicated in the "Participants in HVAC Systems Commissioning" section.
   b. These meetings will be held at the CxA convenience and shall be scheduled on a regular basis.
   c. Other meetings such as the Commissioning Kick-Off Meeting, Update Meetings, Controls Meeting, Submittal Meetings and other Coordination Meetings shall be

attended by those participants as indicated in the "Participants in HVAC Systems Commissioning"

1.4 QUALITY ASSURANCE

A. The commissioning process shall be conducted in accordance with the following reference documents.

1. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 202, Commissioning Process for Building and Systems
2. State of Utah – Department of Administrative Services Division of Facilities Construction and Management (DFCM) Design Requirements, High Performance Building Standards
3. National Environmental Balancing Bureau (NEBB) – Procedural Standards for Whole Building Systems Technical Commissioning
4. Building Commissioning Association (BCxA) – New Construction Building Commissioning Best Practice
5. AABC Commissioning Group Guidelines (ACG) – ACG Commissioning Guideline

1.5 COMMISSONED SYSTEMS

A. Commissioning shall be performed on the following systems and components.

1. Chemical Fume Hoods and Base Cabinets
2. Venturi Air Valves
3. Sound Traps
4. Fume Hood Exhaust Fans
5. Supply Fan Wall Array
6. Plate and Frame Heat Exchanger
7. Dual Duct Variable Air Volume Terminal Units
8. Exhaust Variable Air Volume Terminal Units
9. Relief-Exhaust Fans
10. Air and Dirt Separator
11. Expansion Tanks
12. Inline Exhaust Fans
13. Hydronic Piping
14. Seismic Bracing

PART 2: PRODUCTS (NOT APPLICABLE)

PART 3: EXECUTION

3.1 GENERAL

A. The Subcontractors shall be responsible for performing procedures presented in specification and contract drawings. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Documentation shall be dated and initialed by field engineer or technician performing the work. Final sign-off shall be by the Owner and Commissioning Agent.

B. Provide technicians, instrumentation, and tools to perform functional testing at the direction of the CxA.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors

D. The CxA in cooperation with the HVAC Contractor, Testing and Balancing Contractor, and Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.
F. Simulated conditions may need to be imposed when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
G. The CxA may direct that set points be altered when simulating conditions is not practical.
H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
I. If tests cannot be completed because of a deficiency outside the scope of the HVAC and/or BAS system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.2 TEST INSTRUMENTATION

A. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Contractor
B. The test equipment shall be provided in sufficient quantities to execute functional testing in an expedient fashion.
C. The test equipment shall be suitable for testing and calibration with accuracy and tolerances necessary to demonstrate that system performance is in accordance with the basis of design.
D. Equipment used for functional testing sensors and gauges shall be certified to an accuracy of 10% of the smallest tolerance to be measured. For example, if a temperature gage is required to be ± 2°F, the calibration device must have a minimum accuracy of ± 0.2°F.
E. Instrumentation used for functional testing system performance must have a minimum repeatability and accuracy of ± 1.0% of the acceptance criteria being measured. For example, if a supply temperature of 50°F is being verified, the repeatability and accuracy of the test instrument must be at least ± 0.5°F.
F. The test equipment shall have calibration certification per equipment manufacturer's interval level or within one year if not specified.

3.3 PRE-FUNCTIONAL TESTING

A. Before system start-up begins, the Commissioning Team shall conduct a final installation verification audit. The Subcontractor shall be responsible for completion of work including change orders and punch list items to the Owner's satisfaction. The audit shall include, but not be limited to, checking of:

    1. Piping specialties including balance, control, and isolation valves.
    2. Ductwork specialty items including turning devices, balance, fire, smoke, control dampers, and access doors.
    3. Control sensor types and location.
    4. Identification of piping, valves, equipment, controls, etc.
    5. Major equipment, pumps, valves, starters, gauges, thermometers, etc.
    6. Documentation of prestart-up tests performed, including manufacturer's factory tests.

B. The Subcontractor shall Review and Complete Prefunctional Checklists in accordance with Section 01 91 13 and 23 08 00
C. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
D. The CxA will verify that HVAC and Building Automation systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
E. If work is found to be incomplete, incorrect, or non-functional, the Subcontractor shall correct the deficiency before system start-up work proceeds.
F. The initial Prefunctional Checklists will be provided in the Commissioning Plan. The final checklists may be modifications of the initial checklists, and checklists may be added;

modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.

G. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work as specified in 01 91 13.
H. The Prefunctional Checklists do not represent all the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere
I. The Contractor shall provide a Startup Plan, which shall include the following:

    1. Prefunctional Checklists
    2. Startup and testing procedures and data forms, in accordance with the project specifications, for all equipment and systems within the commissioning scope of work.
    3. Piping testing reports, to be approved by the A/E.
    4. Duct testing reports, to be approved by the A/E.
    5. Water treatment reports, to be approved by the A/E.
    6. Manufacturer's tests.

J. Within 20 working days of Product Submittal approval, submit the Startup Plan with blank forms for CxA review.
K. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
L. Submit the completed Startup Plan prior to functional performance testing. When it is necessary to begin functional performance testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the Startup Plan that have been completed only for the system(s) that are ready for testing.
M. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to Section 01 91 13 General Commissioning Requirements for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.
N. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.4 TESTING AND BALANCING VERIFICATION

A. Prior to performance of testing and balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
B. Notify the CxA at least 10 days in advance of testing and balancing work and provide access for the CxA to witness testing and balancing work.
C. Provide technicians, instrumentation, and tools to verify testing and balancing of systems at the direction of the CxA.

    1. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report.
    2. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

D. The CxA will verify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

3.5 BAS SYSTEM REVIEW

A. Point to Point Checkout: Point to point checkout documentation shall be provided by the Contractor in accordance with the project specifications. The Controls Contractor shall support commissioning by submitting point to point checklists for CxA review and, if necessary, participating in the Commissioning Control System Field Review, in which the Controls Contractor demonstrates specified results to the CxA after completion of final point to point checkout.
B. Graphical User Interface Screenshots: The controls contractor shall submit screenshots of the control system to demonstrate the control system graphical interface is complete and the control system is ready for functional performance testing.
C. Programming: Controls programming shall be provided by the Contractor in accordance with the project specifications. The controls contractor shall submit screenshots (or other documentation) of the actual control system programming for review and approval and to demonstrate the control system programming is complete, programmed per the controls submittal, and is ready for functional performance testing.

3.6 FUNCTIONAL PERFORMANCE TESTING

A. The Functional Performance Test (FPT) Procedures shall be developed, performed, and demonstrated in accordance with Section 01 91 13.
B. At a minimum, the mechanical and TAB contractors are required to participate in developing, performing, and demonstrating the indicated FPTs. In addition, the equipment supplier of the chiller and air handling units shall also assist in performing and demonstrating the indicated FPTs for the associated equipment.
C. The initial FPTs shall be provided after review of the controls submittal. The final FPTs may be modifications of the initial FPTs, and FPTs may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
D. The Contractor’s Commissioning Coordinator shall coordinate the subcontractors, with the Commissioning Authority's input, in developing, performing, and demonstrating the FPTs.
E. Functional testing shall consist of the following four phases:

1. Component testing:

a. Component testing applies to all control input and output devices, including those provided by the equipment suppliers and those provided with the Building Control System. Examples include but are not limited to: sensor assemblies, detectors, relays and switches, valves, dampers, actuators, temperature and pressure sensors, and gauges.
b. Component testing consists of demonstrating field I/O calibration and operation including but not limited to:

i. Accuracy of sensors is within design temperature and pressure range as specified.
ii. Alarmed points report correctly to operator work station.
iii. Accuracy and settings of binary switches and alarms is as specified, within design temperature range
iv. Actuators operate smoothly in a linear relationship with the signal they receive over the full range of operation
v. Fail safe operation of components and controllers is as specified for loss of control signal, electric power, and network communications
vi. All components, values and alarms are correctly mapped to operator interface station

2. Systems Testing – Operational Verification: After functional testing of the system components has been successfully completed, each sequence of operation and control system function shall be functionally tested, including those provided by the equipment suppliers and those provided with the Building Control System. Each control loop shall be tested to verify stable control with the specified and appropriate responses.
3. Systems Testing – Integrated System Verification: After operational testing has successfully demonstrated that each system functions in accordance with the project documents, functional testing shall occur to verify that the interaction between the systems is as required. Each interactive function shall be functionally tested, including those provided by the equipment suppliers and those provided with the Building Control System.
4. Systems Testing – Real Time Performance Analysis (trend logging):
    a. After operational testing has been successfully completed real time performance testing shall be performed. Data shall be logged for the intervals and periods specified in the FPT procedures. Unless otherwise specified in the FPTs, test periods shall include occupied, unoccupied, weekend, and holiday schedules.
    b. Analysis of the data shall demonstrate that that the systems operate in accordance with the acceptance criteria specified in the FPT procedures. Verify that data demonstrates acceptable results before submitting for CA review. If acceptable results are not demonstrated, perform testing and trouble shooting and corrective action to provide resolution. Provisions for retesting, as specified in 01 91 13) shall apply to trend log analysis.

END OF SECTION

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. See Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 SUBMITTALS

A. Product Data: For each control device indicated.

B. Shop Drawings:
1. Schematic flow diagrams.
2. Power, signal, and control wiring diagrams.
3. Details of control panel faces.
4. Damper schedule.
5. Valve schedule.
6. DDC System Hardware: Wiring diagrams, schematic floor plans, and schematic control diagrams.
7. Control System Software: Schematic diagrams, written descriptions, and points list.

C. Software and firmware operational documentation.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Installer Certifications: A certified installer who is an authorized representative, a certified installer, or an approved installer of the automatic control system manufacturer for both installation and maintenance of units required for this Project.

C. Comply with NFPA 90A, “Installation of Air Conditioning and Ventilation Systems.”

1.4 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 21 Section “Fire Alarm” to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 26 Section “Motor-Control Centers” to achieve compatibility with motor starters and annunciation devices.

1.5 SCOPE OF WORK INCLUDED

A. Furnish a Microsoft Windows based Direct Digital Control system (DDCS) in accordance with this specification section. Items of work included are as follows:
   1. Provide all necessary hardware and software to meet the specified functional requirements.
   2. Prepare individual hardware layouts, interconnection drawings and control loop configuration data from project design data.
   3. Implement the detailed design for all system input/output points, distributed control and system data bases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
   4. Design all equipment cabinets, panels, and the data communication network cables including all associated hardware.
   5. Provide and install all cabinets, panels, and data communication network cables including all associated hardware.
   6. Provide and install all interconnecting cables between supplied cabinets, controllers, and output devices.
   7. Provide and install all interconnecting cables between all operator terminals and peripheral devices (such as printers, etc.) supplied under this section.
   8. Provide complete specifications for all items supplies by the Vendor from others (such as printers, instruments, etc.).
   9. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, start-up and commissioning.
   10. Provide a comprehensive operator and technician training program as described herein.
   11. Provide as-built documentation, software, and all DDC control logic and all associated support documentation on approved media which accurately represents the final system.
   12. All control equipment hereinafter specified shall be provided by the Temperature Control Contractor under this section.
   13. All control equipment shall be manufactured by the temperature control companies listed in the bidding section of these documents.
   14. Furnish control components (damper actuators, control valves, DDC controller) to unit ventilator manufacturer for factory installation and testing.

B. Related Work in Other Sections -
   1. Examine all sections for work related to work of this section, principle items of which are:
      a. Finishes Division 09
      b. Mechanical Division 23
      c. Electrical Division 26
   2. The following incidental work shall be performed by the designated contractor under the supervision of the Temperature Control Contractor.
   3. The Plumbing Contractor shall:
      a. Install automatic valves, that are specified to be supplied by the Temperature Control Contractor.
      b. Furnish and install all necessary piping connections required for flow devices and wells.
   4. The Sheet Metal Contractor shall:
      a. Provide access doors or other approved means of access through ducts for service to the control equipment.
      b. Install automatic dampers provided by this section.

1.6 PERFORMANCE

A. Approved DDC control equipment is:
   1. Johnson Controls

1.7 SUBMITTALS

A. The following shall be submitted for Approval:
   1. Provide 6 copies of submittals.
   2. Data sheets for all control systems and components.
   3. Valve schedules, showing sizes, configuration capacity and location of all equipment.
   4. Control system drawings containing pertinent data to provide a functional operating system, including a sequence of operation. Detailed shop drawings may be submitted in an as installed form upon project completion.

B. Drawings:
   1. After completion of contract, the Supplier shall submit review drawings, installation and operation instruction and a recommended spare parts list.
   2. Drawings shall be standard sizes (24 inches x 36 inches) or (11 inches x 17 inches).
   3. Provide three copies of as installed drawings.

C. System documentation by the Vendor shall include the following as a minimum:
   1. System configuration diagrams in simplified block format.
   2. Input/Output point and alarm point summary listing.
   3. Electrical drawings showing all system internal and external connection points, terminal block layouts and terminal identification.
   4. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
   5. Overall system operation and maintenance instructions, including preventive maintenance and troubleshooting instructions.
   6. Complete recommended spare parts list.

1.8 INSPECTION OF CONDITIONS

A. Examine related work and surface before starting work of this section. Report to Architect, in writing conditions which will prevent proper provision of this work. Beginning work of this section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by the contractor. Perform and required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to owner.

1.9 INSTRUCTION AND ADJUSTMENT

A. Upon completion of the project, the Temperature Control Contractor shall adjust and validate all thermostats, controllers, valves, damper operators, relays, etc. provided under this section.

B. Instruction manuals shall be furnished covering the function and operating of the control system on the project for use by the owner's operating personal. An instruction period lasting not less than 16 hours shall be provided to completely familiarize operating personnel with the temperature control system.

1.10 PROVIDE ALL REQUIRED SOFTWARE AS PART OF THIS CONTRACT

A. Provide any upgrades in Software on a no charge basis for a minimum of 2 years after completion of the project. These upgrades will not include any upgrades in hardware necessary for enhancements in the system but will include any maintenance upgrades at no charge.

1.11 PROVIDE ALL TRAINING AS PART OF THIS CONTRACT

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SYSTEM DESIGN

A. Provide a Distributed Processing System complete with Direct Digital Control (DDC) and Direct Analog Control (DAC) software. This system is to control all HVAC equipment and others specified equipment directly, without intervening conventional controls.

B. All DDC Controllers for terminal units, air handlers, central mechanical equipment, and remote or onsite Windows based operators' terminal(s) shall communicate with each other and share information.

C. The controls supplier shall assume complete responsibility for the entire controls system as a single source and shall certify that he has on staff under his direct employ on a day-to-day basis, factory trained technical personnel, certified to engineer, program, debug, and service all portions of the DDC control system, including central remote or onsite system operators terminal, global controllers, terminal unit controllers, and all other portions of the DDC control system.

D. Basic System Features:
   1. Zone by zone DDC control of space temperature, usage scheduling, optimum starting, equipment failure reporting, and override timers for off-hours usage. A zone is the area served by one HVAC terminal unit (VAV box, heat pump, unit ventilator, fan coil, etc.)
   2. Complete energy management firmware, including self-adjusting optimum start, demand limiting, global control strategies and logging routines for use with total control systems. Operators terminal software is to be used for access to remote or onsite field based energy management control firmware only.
   3. Priority password security systems to prevent unauthorized use. Each user shall have an individual password. Each user shall be assigned which control functions they have access to.
   4. Equipment monitoring and alarm function including information for diagnosing equipment problems.
   5. The complete system including, but not limited to terminal unit controllers, Global controllers and Operator terminals shall Auto-restart, without operator intervention, on resumption of power after a power failure. Database stored in Global Controller memory shall be battery backed up for a minimum of 30 days. Unitary controllers shall utilize EEPROM for all variable data storage. Batteries on unitary controllers shall not be allowed.
   6. Modular system design of proven reliability.
   7. Each field panel capable of independent control.
   8. All software and/or firmware interface equipment for connection to remote or onsite operator's terminal including modems at each site specified.
   9. Equipment runtime totalization of fans, heaters, boilers, etc., capable of alarm generation and alarm dial out to remote sites.
   10. Room sensors with digital readout that allow the user to view room temperature, view outside air temperature, adjust the room setpoint within preset limits and set desired override time.

11. Field control devices such as terminal unit controllers shall have optically isolated communication lines. Controllers not opto-isolated and utilizing a ground referenced communication technique are specifically prohibited.
12. Communication wiring for field control devices shall not be dependent on daisy chaining of communication wiring. Communication wire may be run in star patterns, daisy chained or combination of either, allowing units to be added to a communication line easily in the future.
13. All DDC hardware and software shall be designed and manufactured by U.S. corporations. All hardware shall be U.L. listed with integral labels showing rating.

2.3 QUALITY ASSURANCE

A. Responsibility: The supplier of the DDCS shall be responsible for inspection and Quality Assurance (QA) for all materials and workmanship furnished by him.

B. Component Testing: Maximum reliability shall be achieved through extensive use of high-quality, pre-tested components. Each and every controller, sensor, and all other DDC components shall be individually tested by the manufacturer prior to shipment.

C. Tools, Testing and Calibration Equipment: Provide all tools, testing and calibration equipment necessary to ensure reliability and accuracy of the DDCS.

2.4 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of date of Supplier's Proposal, and any subsections thereof as applicable, shall govern design and selection of equipment and material supplied.
   1. ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers.
   2. IBC International Building Code, including local amendments.
   3. UL 916 Underwriters Laboratories Standard for Energy Management Equipment.
   4. NEC National Electrical Code.

B. City, county, state, and federal regulations and codes in effect as of date of purchase.

C. Except as otherwise indicated, vendor shall secure and pay for all permits, inspections, and certifications required for his work and arrange for necessary approvals by the governing authorities.

2.5 SCHEDULING AND COORDINATION

A. The Temperature Control Contractor shall coordinate all installation schedules and component delivery schedules with the General Contractor and Mechanical and Sheet Metal contractor on the job.

2.6 WARRANTY

A. Warranty shall cover all costs for parts, labor, and associated travel, and expenses for a period of one year from completion of system demonstration.

B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the Vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours.

C. This warranty shall apply equally to both hardware and software.

2.7 DDC EQUIPMENT

A. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
   1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
   2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      a. Global communications.
      b. Discrete/digital, analog, and pulse I/O.
      c. Monitoring, controlling, or addressing data points.
   3. Local operator interface provides for download from or upload to operator workstation.

B. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
   1. Binary Inputs: Allow monitoring of on-off signals without external power.
   2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
   3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
   4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
   5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA)
   6. Tri-state Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
   7. Universal I/Os: Provide software selectable binary or analog outputs.

C. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
   1. Output ripple of 5.0 mV maximum peak to peak.
   2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
   3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

2.8 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
   1. Configuration: Diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; and memory with bios.
   2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform automatic system diagnostics; monitor system and report failures.
   3. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.9 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

2.10 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:
   1. Accuracy: Plus or minus 0.5 deg F at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
   4. Averaging Elements in Ducts: 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft.
   5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches.
   6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Exposed.
      b. Set-Point Indication: Exposed.
      c. Thermometer: Exposed.
      d. Color: White.
      e. Orientation: Vertical.
   7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   8. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. RTDs and Transmitters:
   1. Accuracy: Plus or minus 0.2 percent at calibration point.
   2. Wire: Twisted, shielded-pair cable.
   3. Insertion Elements in Ducts: Single point, 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
   4. Averaging Elements in Ducts: 24 inches long, rigid; use where prone to temperature stratification or where ducts are larger than 9 sq. ft.; length as required.
   5. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.
   6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      a. Set-Point Adjustment: Exposed.
      b. Set-Point Indication: Exposed.
      c. Thermometer: Exposed.
      d. Color: White.
      e. Orientation: Vertical.
   7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
   8. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

D. Pressure Transmitters/Transducers:
   1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
      a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
      b. Output: 4 to 20 mA.
      c. Building Static-Pressure Range: 0- to 0.25-inch wg.
      d. Duct Static-Pressure Range: 0- to 5-inch wg.
   2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to 300-psig; linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas or liquid service; range suitable for system; linear output 4 to 20 mA.

E. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1. Set-Point Adjustment: Exposed.
2. Set-Point Indication: Exposed.
3. Thermometer: Exposed.
4. Color: White.
5. Orientation: Vertical.

F. Room sensor accessories include the following:
1. Insulating Bases: For sensors located on exterior walls.
2. Guards: Metal wire, tamperproof.
3. Adjusting Key: As required for calibration and cover screws.

2.11 STATUS SENSORS

A. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

B. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

C. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

D. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

E. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and O/2- to 10-V dc, feedback signal.

2.12 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Requirements."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running and breakaway torque of 150 in. x lbf.
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.

6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Manufacturers:
   a. Belimo Aircontrols (USA), Inc.
2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:
   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating 40 to 104 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Run Time: 12 seconds open, 5 seconds closed.

2.13 DAMPERS

A. Manufacturers:
1. Johnson Controls Inc. D-1300
2. Ruskin Inc.

B. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch-minimum thick, galvanized-steel or 0.125-inch-minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch-thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
1. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.

2.14 STEAM CONTROL VALVES

A. Manufacturers:
1. Johnson Controls VG1000

2. BELIMO

B. All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved.

2.15 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Division 16 Section "Voice and Data Communication Cabling."

2.16 TERMINAL UNIT CONTROLLERS

A. General:
1. Provide programmable and application specific Terminal Unit Controller as needed to comply with sequence of operation, point list and drawings. All Terminal Unit Controller units shall be completely stand-alone with no loss of control if communication with global controller is interrupted. All control parameters, DDC programs and local variables such as setpoint information shall be stored in EEPROM on board each Terminal Unit Controller allowing the operator to change information as desired. Controllers that utilize a battery to backup control parameters, etc., shall not be allowed.
2. All points on drawings, in sequence of operation and on point list shall be connected to and controlled by DDC units. No control shall be done by external devices such as thermostats or analog controls that are not part of the DDC system.
3. Programmable Terminal Unit Controllers shall be used in custom applications such as central plant, build up air handlers, fume hoods, or when application specific controllers sequence of operation is not applicable.
4. Communication from Global controller to Terminal Unit Controllers shall be via two wire communication trunk as specified for Global Controllers above. Any type of Terminal Unit Controller shall communicate on the same communication trunk. System shall communicate to one Terminal Unit Controller regardless of whether other Terminal Unit Controllers on the same communication line are powered and connected. Ground referenced communications is prohibited.
5. Global controller shall communicate to all field controllers manufacturer has made in the past as well as currently.

B. Programmable Terminal Unit Controllers
1. Each programmable Terminal Unit Controller shall be completely programmable from the system terminal, via field computer or via remote communications. Program execution rate shall be ten times per second minimum (once every 100 milliseconds).
2. This controller shall be programmed to perform custom strategies for system based on information from all points in the field. Program that implements these strategies shall be completely flexible and user definable. Any controllers utilizing factory programmed strategies that cannot be modified by field personnel on site, require factory assistance, or cannot be downloaded via remote communications are not acceptable. Changing strategies via firmware changes is also unacceptable.
3. Programming shall be object oriented using program blocks familiar to control specialists for all program strategies. Provide documentation in flow chart form for all programming. Include samples of flow chart documentation in submittals. All flow charts shall be generated with CAD system and automatically downloaded to controller. No re-entry of data base shall be necessary. As-built documentation of all software shall be provided to end user in flow chart form at completion of project.
4. Program and program parameters such as set points shall be stored in EEPROM. Battery backed RAM shall not be accepted for this level of controller.

5. All inputs shall be universal in that they accept analog and digital information. Inputs shall be capable of detecting a 0.1 second momentary closure. Analog inputs shall be capable of accepting thermistor inputs, 0 t 5 VDC, 0 to 10 VDC, or 4 to 20 mA inputs. No external hardware shall need to be added for Terminal Unit Controller to accept these different types of inputs. All inputs shall utilize a minimum of 10 bit analog to digital conversion.
6. Outputs shall have minimum control resolution of 0.1 seconds On or Off.
7. Each of the analog outputs shall be independently switch selectable to output 0 to 10 VDC or 4 to 20 mA. Unit shall be programmable to output a sub range of voltage or current to match the device controlled. Analog outputs shall use 8 bit digital to analog conversion.
8. Terminal Unit Controller may be programmed to control what is displayed on zone sensor display. See section 2.5. Terminal Unit Controller may be programmed to show alpha numeric values on zone sensor display in response to program changes or button presses on the zone sensor.
9. Each Terminal Unit Controller shall provide 24 VDC at 250 mA as a source of power for current transducer sensors in the field.

C. Application Specific Terminal Unit Controllers:
1. Application Specific Terminal Unit Controllers shall be completely stand-alone controllers for unitary type controls such as VAV terminal boxes, heat pumps, AC units, unit ventilators, etc. All programs shall be resident in controller for complete stand-alone operation.
2. EEPROM technology shall be used for storage of program parameters such as set points, limits, etc., controllers utilizing a battery for backup of program parameters shall not be allowed.
3. All application specific Terminal Unit Controller units shall have capability to use Digital display zone sensor, or thermistor type zone sensor as listed in section 2.5.

2.17 OPERATOR FIELD INTERFACE DEVICE

A. Hardware:
1. Operator field interface shall communicate to global controller via RS-485 at 38.4K baud minimum. RS-232 port shall be available on front of device for reprogramming displays. This port shall be accessible without removing any covers from unit.
2. Provide minimum of 128K or nonvolatile RAM for display storage and 32K of EPROM. Battery shall retain memory for 30 days minimum.
3. Operator interface device shall be housed in plastic enclosure suitable for mounting in office area. Device shall be separate unit from global controller and mount on standard double wide box.

B. Displays:
1. Operator Terminal shall display all data associated with project as called out on drawings and/or point list supplied. Information shall be labeled with English descriptions on display and shall be shown in engineering units as labeled (i.e., temperature shall be displayed in degrees F, 72.3F). Terminal shall allow user to change all EMS functions associated with the project such as set points, time schedules, holiday schedules, etc. with single button push. This shall be done without a reference to point addresses or other numeric/mnemonic indications.
2. All displays shall be generated and customized in such a manner by local DDCS supplier that they fit the project as specified. No canned displays that are modifiable only by factory personnel shall be acceptable. Displays shall use standard English for labeling and readout.
3. Menu system shall be used for display selection. Menu items on display shall allow penetration to lower level displays. Dynamic point information and menu items may be mixed on the same display to allow sub displays to exist for each item. Each display may

be protected from viewing unless operator has appropriate security level. Display security level may be assigned to each display.

4. All dynamic point information shall be updated every 1 second. Any changes by the operator shall be acted on by devices in the field within 2 seconds.
5. Cursor keys shall be used to move cursor to desired item for selection of new display or to allow the operator to make changes. Entry of name to view or change data shall not be necessary.
6. Displays may be modified on site or via remote communications.

C. Security System:
1. Provide security system that prevents unauthorized use unless operator is logged on. Access shall be limited to operator terminal's functions unless user is logged on. This includes displays as outlined above.
2. Operator's Terminal shall access passwords from global controller that are user definable. Each password may have one of 10 security levels that define extent of access for operator once logged on with that password.

2.18 TEMPERATURE SENSORS

A. General:
1. All temperature sensors to be solid state electronic, factory calibrated to within one-half degree F, totally interchangeable. Wall sensors to be housed in enclosure appropriate for application. Duct and well sensors to be electronically identical with housing appropriate for application. Provide appropriate wells for installation by others.
2. Outside air sensor shall be located on north wall in location that is not subject to vandalism.

B. Zone Temperature Sensor:
1. Sensor shall contain override switch, electronic sensor, setpoint bias lever and jack for connection to Digital Display zone sensor for troubleshooting. The operator shall program the time of an after hours override operation from 0.0, no override, to 9.9 hours in 0. hour increments. Push buttons are to remain inactive until zone is in the after hours mode.
2. Setpoint bias shall be via labeled up/down buttons. Maximums bias shall be plus or minus 3 degrees F.
3. Override switch shall be located on sensor housing.
4. Digital display shows setpoint, room and outside air temperature.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above the floor.
1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

B. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

C. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

D. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."

E. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.2 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceways and Boxes."

B. Electric wiring and wiring connections required for the installation of the temperature control system as herein specified, shall be provided by the Temperature Control Contractor unless specifically shown on the drawings or called for in the specifications to be by the electrical contractor.

C. Install building wire and cable according to Division 26 Section "Low-Voltage Electric Power Conductors and Cables."
   1. Conceal cable and raceway, except in mechanical rooms and areas where other conduit and piping are exposed. Wiring in finished areas may be in wiremold (where previously approved by Architect).
   2. Install exposed and concealed cable in raceway (where drop ceiling plenum exists, raceway may be omitted in that area only – use plenum rated cable).
   3. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   4. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   5. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   6. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
   7. All in drop ceiling plenum wiring shall be securely fastened upon using nylon wire ties. All wiring shall be installed in a net workmanlike manner.
   8. Where raceway is installed, provide flexible connection to all vibrating equipment. Flexible conduit shall be a maximum length of three (3) feet only.
   9. All ATC rough-in boxes shall be identified with the letters “ATC” written across the inside of the box. In addition, each ATC cover plate shall be painted white with the letters “ATC” stenciled in black. Surface conduit may be installed as allowed by architect with color selected by architect

D. All wiring shall be installed according to the National Electrical Code and local codes.

E. Wiring and required relays from the building fire alarm panel for fan shutdown shall be furnished and installed by the Temperature Control Contractor.

F. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

G. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   2. Test and adjust controls and safeties.
   3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.

4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:
1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
6. Check temperature instruments and material and length of sensing elements.
7. Check control valves. Verify that they are in correct direction.
8. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
9. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 230900

SECTION 230991 – LABORATORY AIRFLOW CONTROL SYSTEM WITH FUME HOODS

PART 1 - GENERAL

1.1 SUMMARY

1. The laboratory Airflow Control System (LACS) will be furnished and installed to control the laboratory environment. The exhaust flow rate of the laboratory fume hood exhaust shall be controlled to maintain a constant average face velocity and the exhaust flow rate of the general exhaust shall be controlled to maintain minimum ventilation rates while also modulating for proper temperature control. The LACS will control the makeup/supply air volume to a volumetric offset to maintain room pressurization.

1.2 REFERENCES

A. Abbreviations and Acronyms (Specific to Critical Room Controls (CRC))
1. BMS – Building Management System
2. BAS – Building Automation System
3. LACS – Laboratory Airflow Control System
4. VAV – Variable Air Volume
5. DPT – Differential pressure transducer
6. ZPS – Zone Presence Sensor
7. IRC – Integrated Room Controller
8. IRM – Integrated Room Monitor
9. CLV – Closed Loop Venturi Valve
10. FHC – Fume Hood Controller
11. PM – Pressure Monitor
12. MV – MultiVIEW Monitor
13. MPV – Mechanical Plunger Valve
14. TAB – Test Adjust Balance

B. Reference Standards
1. BTL
2. UL
3. ANSI/ASHRAE 130
4. ANSI/ASHRAE 135

1.3 SUBMITTALS

A. Product Data:
1. Submit product data for valve electronic and electrical components and optional accessories.
2. Each air valve model product name, model ordering number, design airflow rates and pressure loss across the valve range.

B. Record Documents:
1. Submit complete point-to-point wiring diagrams for each applicable room configuration as shown on the Owner's Drawings.

1.4 WARRANTY

A. Warranty on manufactured equipment will commence upon date of shipment and extend for a period of sixty (60) months, wherein any defects in materials will be repaired by the supplier at no cost to the owner.

B. The system shall also have a one year parts and labor warrantee starting from the date of substantial completion.

1.5 DESIGN CRITERIA

A. Unit manufacturer, or designated representative, will be required to verify air valve device performance and adjust or replace device(s) within warranty period when it is determined that problem exists in area served by device(s).

B. Actuators shall be furnished, and factory installed by LACS Manufacturer.

C. Actuators shall be high-speed fail-safe or fail-in-place electronic type.

D. Actuator and its controller shall be calibrated, and field set through TAB work for scheduled airflow rates. Air valves shall be capable of field calibration, characterization, and adjustment.

E. Provide all components not specifically indicated or specified, but necessary to make system function within intent of specification an di accordance with control sequences.

F. Size all control apparatus including all air valves to provide stable control of systems and equipment served throughout specified operating range.

G. Any devices subject to corrosion, such as in fume hood exhaust valves, shall manufactured of stainless steel, appropriate corrosion protection. Unless otherwise noted, air valve material and method of pressure and temperature rating shall match that of the ductwork where the valve is installed.

1.6 TRAINING

A. Provide minimum of 8 hours of on-site training. Conduct training sessions during normal working hours after system start-up and acceptance. Portions of training may be performed before system is completely operational. Final training session shall be held after systems are complete.

B. Training sessions shall include, but not limited to, the following topics:
   1. Explanation of control sequences. Include which sensors are used and how output device operates.
   2. Explanation of control drawings and manuals, including symbols, abbreviations, and overall organization.
   3. Walk-through of project to identify controller locations and general routing of cabling.
   4. Review of operation and maintenance of hardware devices including controllers, instruments, and sensors. Include schedule for routine maintenance.

1.7 COORDINATION

A. Coordinate installation of air valves, sensors, controllers and wiring with other trades as required. Coordination drawings shall clearly illustrate installation methods and access provisions for all devices.

PART 2 - LABORATORY AIRFLOW CONTROL SYSTEM (LACS)

2.1 MANUFACTURERS

A. Basis of design is critical room controls (CRC), other manufacturers may be considered by the owner given they perform and achieve all drawing and specification requirements and provide a redesigned

layout during the contractor questions phase of bidding that clearly identifies differences in operation, control interlace to JCI, HVAC system requirements, electrical requirements, and physical space requirements. Other manufacturers will be added, if acceptable, by addendum.

2.2 GENERAL

A. The Laboratory Airflow Control System (LACS) will control the Primary (Hoods) and Secondary (Room) containment zones. The LACS will maintain volumetric offset to achieve room pressurization in relation to adjacent spaces. The LACS will interface with laboratory fume hood exhaust controlling the fume hood constant average face velocity. The LACS will also provide temperature, and environmental control while maintaining minimum ventilation rates as per design schedule.

B. LACS devices will include the Integrated Room Controller (IRC) with an Integrated Room Display (PM) located at each entrance, and Integrated Room Display (MV) located inside the lab, and Fume Hood Controller (FHC) located on each fume hood. Each user interface shall communicate clear, unambiguous indication of the fume hood or current lab condition and mode in plain language via full color touch screen.

C. All room level control shall be hardwired inputs and outputs. Systems utilizing network communication or proprietary communication languages shall not be accepted. LACS controllers shall be configurable through local touch screen display(s) and not require additional proprietary software for setup or commissioning.

D. Each laboratory shall have a dedicated LACS to operate stand-alone from the building automation system. System shall not use or rely on information from controllers in other laboratory areas or from outside laboratory space to control functions within its laboratory.

2.3 LACS CONTROL STRATEGIES

A. Airflow control shall be volumetric offset to maintain secondary containment and pressurization.
   1. The LACS shall continuously measure the sum of all exhaust air valves and the sum of all supply air valves and maintain a constant offset based on measured airflows.
   2. Volumetric offset tracking shall ensure supply air set point is determined from measured total exhaust airflow. Systems utilizing independent set points not based on measured values shall not be acceptable.
   3. The LACS shall maintain proper room pressurization regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or changes induct static pressure. Systems achieving room pressurization control by means of direct pressure control are unacceptable.

B. Temperature control shall utilize dual loop and variable ventilation rates to maintain temperature.
   1. The LACS shall use dual loop temperature control on all rooms serving critical spaces to maintain consistent room temperatures regardless of air volume changes.
   2. The LACS shall continuously measure both room temperature and supply air duct temperature. The LACS shall modulate the hot deck and cold deck to maintain room temperature.
   3. The LACS shall modulate the hot deck from minimum to maximum based on the calculated demand of heating.
   4. The LACS shall modulate the cold deck from minimum to maximum based on the calculated demand of cooling.
   5. The LACS shall maintain the hot and cold deck valve position last commanded to achieve proper temperature control when temperature is within Deadband.

2.4 EQUIPMENT

A. Controller
1. Basis of Design:
a. Integrated Room Controller (IRC)
1. Room shall consist of one controller for room level control. Each air valve shall not require a controller for the LACS to operate.
2. Controller shall utilize analog signals (scaled voltage) to control air valves. Room level networks shall not be acceptable.
3. Controller shall be BACnet native, BTL Listed, and utilize BACnet MS/TP communication protocol for integration.
4. Controller shall be application specific for volumetric offset control and not require logic-based programming.
5. Controller shall be configurable through local environmental condition display (password protection optional).
6. Controller shall serve as power source for all sensors within the LACS.
7. Controller shall support up to five modes that each have customizable parameters, alarms, set points, etc.
8. Environmental Condition Display
a) The display shall be wall mounted and capable to be mounted up to 200’ from IRC.
b) Each display shall be a 7-inch resistive touch screen display capable of sensing touch with a gloved hand.
c) The IRC shall support multiple display formats for environmental condition with information in an icon or pill-based display. Refer to project plans for display types.
(1) PM – Pressure Monitor view with full color background and icon for room condition. Points of information accessible from slider bar at bottom of display.
(2) MV – MultiVIEW Monitor view with point of information displayed in pill format. Ability to swipe screen to view points of information.
d) User Defined Modes:
(1) 15-character customizable name text.
(2) Background color customizable, including, but not limited to; green, blue, red, yellow, grey, etc.
(3) Monitor icon customizable, including, but not limited to; patient bed, surgeon mask, beaker, stop hand, caution triangle, mop, etc.
(4) Customizable set points per mode
(5) Modes shall be able to be changed locally from display, through the building automation system or through hardware signal.
e) Displayed Information
(1) The room pressure monitor shall have the ability to display 28 points of information.
(2) Each point shall be fully customizable from the display
(3) Each point shall include:
(a) 15-character customizable point name
(b) Engineering unit customizable: including, but not limited to, CFM, “WC, ACH, %, °, etc.
(c) Resolution selection of 0 to 0.0000
(d) Ability to hide, show or adjust set points
(e) Customizable alarm parameters
(4) Displayed information shall be configurable from (14) analog inputs and/or writable through the building automation system.
f) Alarm and Security:
(1) The monitor shall include audible and visual alarming customizable for each point of information, including, but not limited to; low pressure, high pressure, emergency condition, temperature, humidity, ACH, etc.

(2) Each point of information within the room pressure monitor shall have ability to enable or disable alarming for each user defined mode.
(3) Each point of information within the room pressure monitor shall have user defined alarm delay.
(a) During alarm delay the display shall have visual indication of point outside alarm parameters.
(4) The display and/or through the BAS, shall have the ability to mute alarms while maintaining visual alarm state.
(5) The display shall have the ability to alarm individual point or entire display screen; with the screen alarm being a pulsated visual.
(6) Each display shall utilize four levels of password-protected access. Different levels of secure access shall include: administrative, mode change, more information, and set point.
(7) Each display shall include up to three unique user passwords and each user be configurable for level of access.

9. Building Automation System (BAS) Interface:
   a) The environmental condition display shall allow BAS to write points of information to be displayed.
   b) The environmental condition display shall allow settings adjustments over the building network, including, but not limited to; set point, alarm parameters, modes, etc.
   c) The BMS shall use either analog inputs, digital inputs, or utilize BACnet network protocol to view points or status of the room being measured. The use of BACnet protocol shall be native to the device and shall not require the use of an external gateway.
   d) The display shall include the ability to change MAC address, device instance ID, and baud rate (9600, 19200, 38400, 76800, 115200) without the use of rotary dial or dip switches.

b. Fume Hood Controller (FHC)
   1. Provide an individual Fume Hood Controller (FHC) for each fume hood, which shall maintain face velocity set point in response to sash position.
   2. The FHC shall maintain a constant face velocity of set point as fume hood sashes are opened and closed.
   3. Controller shall modulate exhaust airflow between minimum and maximum airflow rates scheduled in Air Valve Device Schedules.
   4. The FHC shall share the measured CFM through scaled voltage (0-10VDC) hardwire and not rely on network communication to room level device.
   5. The FHC shall utilize field characterization of the venturi air valve to ensure speed of response.
   6. The FHC will continually measure the fume hood's total open area. Fume hood total open area will be based on fume hood sash position including fume hood fixed opening(s), bypass and leakage. The total open sash area calculation will be used to determine the required fume hood exhaust airflow to maintain the specified average face velocity set point.
   7. The FHC shall be configurable for:
      a) Volumetric control with vertical sash (VSS)
      b) Velocity control with sidewall sensing (SVS)
      c) Volumetric control with horizontal sash sensing (HSS)
      d) Volumetric control with combination vertical and horizontal sash sensing (CSS)
      e) Constant volume control (CVC)
   8. The Vertical Sash Sensor (VSS) shall consist of a precision measurement reel connected to a spring return cable assembly. The combined resolution and accuracy shall not exceed 0.25%. The VSS shall be mounted in a concealed location and coordinated with fume hood manufacturer. Control system shall measure full opening range of hood sash 0% to 100%.

9. The Horizontal Sash Sensor (HSS) shall consist of flat bars to be affixed to the horizontal sash panels or sash frame based on hood manufacturer. The HASS shall measure the horizontal sash panel overlap area and calculate the total sash open area.
10. The Combination Sash Sensor (CSS) shall consist of both vertical (VSS) and horizontal (HSS) strategies. The control logic shall measure both areas in a dynamic equation for calculating total sash open area.
11. The Sidewall Velocity Sensor (SVS) shall consist of a precision dual-path, rapid speed of response velocity measurement device. Control system shall measure velocity of full opening range of vertical, horizontal, or combination sash configurations. Sidewall sensor utilizing single path hot wire anemometer is not acceptable.
12. The fume hood display and controller shall be capable of:
    a) Variable Volume Control
    b) Constant Volume Control
    c) Two position In Use / Standby flow control
13. The FHC shall include the following modes:
    a) In Use (adjustable constant face velocity set point)
    b) Standby (adjustable constant face velocity set point)
    c) Emergency override (maximum hood airflow)
    d) Decommission (fume hood shut down zero flow)
        (1) FHC shall automatically change to “In Use” mode on a movement of sash position.

c. Fume Hood Display
1. Provide an individual fume hood full color touch screen display located on the efface of each fume hood.
2. Fume hood display shall have programable password protection.
3. All fume hood functions, variables and commissioning such as face velocity set point, minimum exhaust flow, alarm thresholds, sash calibration, etc. will be accessed from the fume hood display without the need of an additional programming tool.
4. During In Use operation, display will have a green background and display current mode, current face velocity (FPM) or air volume (CFM), sash opening, alarms, operating conditions and indication of status. If the fume hood is not maintaining proper operation, the FHC will have red background, indicate loss of flow and audible alarm. When in alarm, monitor will prompt user to close sash.
5. Fume hood display shall have a separate visual and audible alarm for sash position alarming. This alarm shall be different than unsafe condition and shall include a delay period (adjustable). The sash alarm shall be able to be acknowledged and silenced.

B. Venturi Air Valves:
1. Basis of Design:
a. Closed Loop Venturi (CLV) by Critical Room Control
1. Valve type shall be closed loop precision feedback venturi anemometer through manifolded venturi sensing.
2. Direct pressure measurement by means of dead ended silicon imbedded glass sensing device. Thermal based pressure measurement devices are not acceptable.
3. Flow sensing that bisects and/or obstructs the duct shall not be acceptable.
4. The valve shall be pressure independent over a static pressure range of minimum of .005” to 5” W.C.
5. Shall not be limited by air velocity and will produce an airflow signal throughout full open to full shutoff.
6. Shall not be limited by minimum duct air velocities for flow signal.
7. No inlet or outlet duct diameters shall be required for accuracy and/or pressure independence.
    a) Suppliers of airflow devices requiring minimum duct diameters will provide revised duct layouts showing the straight duct runs upstream and downstream of these devices. In addition, suppliers shall include static pressure loss calculations as part

of their submittals. All costs to modify the ductwork, increase fan sizes and horsepower and all associated electrical changes shall be the responsibility of the LACS supplier.

8. Valve shall have no axis of orientation mounting requirement for accuracy and/or pressure independence.
9. Air valve shall be capable of a turndown of 10:1 maintaining an accuracy of ±5% of measured flow.
10. Airflow measuring devices that require a minimum velocity for flow feedback shall provide a secondary flow measurement device for velocities below published manufactures minimum.
11. Valves shall be capable of being mounted in any position and orientation.
12. Based on application the air valve shall be manufactured as follows:
    a) Non-corrosive (Supply, Return and General Exhaust): The valve shall be constructed from 16-gauge aluminum or Galvanized body. The valve shall have 316 stainless steel single blade elliptical damper mounted on a solid stainless-steel shaft with corrosive resistant shaft bearings.
    b) Corrosive (Valves mounted in Stainless Steel Ducts, Fume Hoods, BSCs, Wash Equipment, Autoclaves, VHP Exhaust): The valve shall be constructed from 18-gauge 304 or 316 stainless steel body. The valve shall have 316 stainless steel single blade elliptical damper mounted on a solid stainless-steel shaft with corrosive resistant shaft bearings.
        (1) Additional coatings shall be specified based on environmental controls. Coatings include phenolic, Teflon, or PVC.
13. The venturi airflow device shall be capable of shutoff with leakage <0.05% of a maximum designed air valve flow at 6” W.C.
14. The valve response signal shall be <25 milliseconds.
15. The venturi airflow valve shall achieve 90% of desired set point in < 1 second.
16. Airflow valves shall be low pressure designed to operate at maximum static pressure drop of 0.225” W.C.
17. Airflow valves shall be configured for [FAIL-SAFE] or [FAIL-IN-PLACE] operation on a loss of power.
18. Electric modulating actuator shall be factory mounted. Valve shall have fast acting actuators, [FAIL-IN-PLACE] or [FAIL-SAFE] as required by LACS.
19. Floating point actuators are not acceptable.

2.5 INTERFACE TO BUILDING MANAGEMENT SYSTEMS

A. The Laboratory airflow control system shall have the capability to interface with the Johnson Controls BMS. All room-level points shall be available to the BMS for monitoring and trending. All set point shall be available to the BMS for configurations. Point’s lists shall be provided based on design requirements.

2.6 DUCT SILENCERS

A. Valves shall be provided with sound trap (neutralizer) where scheduled.

PART 3 – EXECUTION

3.1 GENERAL

A. Furnish and install fume hood monitors, zone presence sensors and sash sensors at each fume hood. Coordinate installation requirements with fume hood manufacturer.

B. Coordinate with ductwork configuration to allow for accurate measurement and control of airflow.

C. Furnish, install and terminate all low voltage control wiring and 24 VAC power supplies.

3.2 AIR VALVES

A. LACS will be capable to provide all required ductwork transitions as required for mounting equipment.

B. Mount actuators on same side of air valve device as coil connections to ensure service access.

C. Connect air valves to ductwork with joints as detailed.

3.3 FUME HOOD CONTROLS

A. Furnish to fume hood manufacturer templates for required hood mounted devices including vertical and horizontal sash sensors, interface boxes, and fume hood monitors required for complete installation of fume hood exhaust air control system. Fume hood manufacturer shall provide necessary cut outs with blank cover plates.

B. Fume hood size and sash configuration are called out in Lab Furnishings documents. Verify with fume hood manufacturer fume hood sizes, sash configurations and installation requirements for each device

C. Field install, mount and wire required hood mounted devices.

3.4 CONTROL AND POWER WIRING

A. Provide control wiring from laboratory control panel to and between other laboratory control system components as required for complete and proper functioning, including but not limited to air valves, control valves, sensors, transducers, controllers, panels, and condition displays.

B. Utilize designated 20-amp circuit at emergency power electrical panel, serving laboratory. Provide required conduit, wire, junction boxes, disconnect switches and circuit breakers as specified in Division 26 as required to wire electrical panel to each laboratory control panel.

C. Wire and Cable shall be installed without splices between control devices and in accordance with NFPA 70 and NFPA 90A. Instrumentation grounding shall be installed per the device manufacturer's instructions and as necessary to prevent ground loops, noise, and surges from adversely affecting operation of the system. Ground rods installed by the Contractor shall be tested as specified in IEEE Std. 142. Cables and conductor wires shall be tagged at both ends, with the identifier shown on the shop drawings. Electrical work shall be as specified in Section.

3.5 EQUIPMENT START-UP, CALIBRATION AND TRAINING

A. The manufacturer or a factory-authorized representative shall perform system start-up. Star-up shall include calibration of fume hood controllers mounted on fume hoods. Calibration shall be performed only after substantial completion of the building. Ceilings and doors shall be installed and the HVAC

systems (exhaust and supply fans) shall be properly air-balanced. The balancing contractor shall be responsible for final verification and reporting of all air flows.

B. The manufacturer or a factory-authorized representative shall provide training for building personnel.

PART 4 – SEQUENCE OF CONTROL

A. SEE CONTROL SEQUENCES ON PLANS

END OF SECTION 230991

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Dielectric unions.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Steel Support Welding Certifications: Procedures and personnel shall comply with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Certifications: Procedures and operators shall comply with ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a certified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:
1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig or less.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.

3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   2. Threaded Ends: Comply with ASME B1.20.1.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. Natural Gas Valves, 2” and Smaller
   1. University Approved Vendor/Manufacturer
      a. Apollo G-B-10 (basis for U of U Specifications)
      b. Nibco GB1A or GB2A (side restricted).
      c. For other products/manufacturers, prior approval is required.

2.5 DIELECTRIC UNIONS

A. Dielectric Unions:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. A.Y. McDonald Mfg. Co.
      b. Capitol Manufacturing Company
      c. Central Plastics Company
      d. HART Industrial Unions, LLC
      e. Jomar Valve
      f. Matco-Norca
      g. WATTS
      h. Wilkins
      i. Zurn Industries, LLC
   2. 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.

PART 3 - EXECUTION

3.1 INDOOR PIPING INSTALLATION

A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

B. 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.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at each appliance and at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
   1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view as required by AHJ.

O. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

P. Connect branch piping from top or side of horizontal piping.

Q. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment.

R. Do not use natural-gas piping as grounding electrode.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.2 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

C. Install earthquake valves aboveground outside buildings according to listing.

D. Install anode for metallic valves in underground PE piping.

3.3 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:
1. Construct joints according to AWS D10.12/D10.12M, using certified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameter, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for corrugated stainless-steel tubing, with maximum horizontal spacing and minimum rod diameter, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping within 12 inches of each fitting.

F. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

G. Support vertical runs of corrugated stainless-steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.6 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.7 FIELD QUALITY CONTROL

A. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 INDOOR PIPING SCHEDULE

A. Aboveground, branch piping NPS 1 and smaller shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping NPS 2.5 inches and larger shall be one of the following:
   1. Steel pipe with malleable-iron fittings and threaded joints.
   2. Steel pipe with wrought-steel fittings and welded joints.

C. Aboveground piping installed in plenums and concealed locations shall be the following:
   1. Steel piping with wrought steel fittings and welded joints.

END OF SECTION 231123

SECTION 233113 - METAL DUCTS

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. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:
1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Certifications: Procedures and personnel shall comply with the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

1.6 FIELD VERIFICATION

A. No ductwork shall be fabricated without first field verifying that the available space under actual job conditions will permit installation of the ductwork without structure or other conflicts. Duct sizes that require on the job modification due to unforeseen obstructions shall be made without any addition cost to the owner.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. 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 ROUND AND FLAT-OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA’S “HVAC Duct Construction Standards – Metal and Flexible,“ Chapter 3, “Round Oval, and Flexible Duct,” based on indicated static pressure class unless otherwise indicated.

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. Linx Industries (formerly Lindab)
   2. McGill Airflow LLC
   3. SEMCO Incorporated
   4. Sheet Metal Connectors
   5. Spiral Manufacturing Co., Inc.

C. 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).

D. Transverse Joints: Select joint types and fabricate according to SMACNA’s “HVAC Duct Construction Standards – Metal and Flexible,” Figure 2-1, “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 24 Inches in Diameter: Flanged.

E. Longitudinal Seams: Select seam types and fabricate according to 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 60 inches in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 60 inches in width (major dimension) with butt-welded longitudinal seams.

F. Tees and Laterals: Select types and fabricate according to 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."

2.3 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.

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 shall 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 shall be Pittsburgh lock seams unless otherwise specified for specific application.
1. Where specified for specific applications, all joints shall 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."

2.4 SINGLE-WALL ROUND AND FLAT OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: All ducts shall be spiral type and shall 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the work include, but not limited to, the following:
   a. Ductmate Industries, Inc.
   b. Elgen Manufacturing
   c. Linx Industries (formerly Lindab).

d. McGill AirFlow LLC
e. Metco
f. MKT Metal Manufacturing
g. Nordfab Ducting
h. SEMCO LLC.
i. Set Duct Manufacturing
j. Sheet Metal Connectors, Inc.
k. Spiral Manufacturing Co., Inc.
l. Spiral Type
m. Stamped Fittings Inc.
n. Superior Sheet Metal
o. Ventline
p. Western

B. 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).

C. 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 24 Inches in Diameter: Flanged.

D. 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." Seams on non-residential projects shall be spiral type.
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.

E. 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."

2.5 DUCT LINER

A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
1. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
a. Thickness: 1 inch.
b. Thermal Conductivity (k-Value): 0.24 at 75 deg F mean temperature.
c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
d. Liner Adhesive: Comply with NFPA 90A or NPFA 90B with ASTM C 916.
e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

1) Tensile Strength: Indefinitely sustain a 50-lb-tensile, dead-load test perpendicular to duct wall.
2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2. Install liner in all square and rectangular supply, return, mixed air, exhaust and transfer air ducts and plenums. Duct dimensions on drawings are clear inside dimensions.

B. Acoustical Insulation, Duct Lining:
1. University approved vendor/manufacturer:
a. Schuller Permacote Linacoustic
b. CertainTeed Ultralite with Certa*Edge Coat
c. Owens Corning QuietR
d. For other products/manufacturers, prior approval is required.

2.6 APPLICATION OF LINER IN RECTANGULAR DUCTS

A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.

B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal noising.

C. Butt transverse joints without gaps and coat joint with adhesive.

D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.

E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.

F. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.

G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 189 inches longitudinally.

H. Secure transversely oriented liner edges facing the airstream with metal noisings that have either channel or “Z” profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
1. Fan discharges.
2. Intervals of lined duct preceding unlined duct.
3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.

I. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
1. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

J. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts; screws, rivets or welds.

2.7 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 shall 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: G60.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

E. 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.

F. 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.

2.8 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall 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.
   10. Sealant shall have a VOC content of 420 g/L or less.
   11. 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. 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.
10. Sealant shall have a VOC content of 420 g/L or less.
11. 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."
12. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
13. Service: Indoor or outdoor.
14. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. 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.
6. Sealant shall have a VOC content of 420 g/L or less.
7. 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. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for10-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.

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 233300 "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 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:
   1. Ductwork shall be galvanized steel.
      a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."
   2. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.4 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 A.
   4. Outdoor, Return-Air Ducts: Seal Class A.
   5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
   6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
   7. Unconditioned Space, Exhaust Ducts: Seal Class A.
   8. Unconditioned Space, Return-Air Ducts: Seal Class A.
   9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
   10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
   11. Conditioned Space, Exhaust Ducts: Seal Class A.
   12. Conditioned Space, Return-Air Ducts: Seal Class A.

3.5 FIELD QUALITY CONTROL

A. Perform test and inspections.

B. Leakage Tests:
   1. Comply with SMACNA’s “HVAC Air Duct Leakage Test Manual.” Submit a test report for each test.
   2. Test and Following System:
      a. Ducts with a Pressure Class Higher Than 3-In wg: Test representative duct sections, totaling no less than 25 percent of total installed duct for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing, and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.
   1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
   2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:
   1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
   2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. 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.
   7. Dedicated exhaust and ventilation components and makeup air systems.

G. 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. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
   5. 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.

6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 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, Furnaces, Heat Pumps, Terminal Units and Rooftop Units (0-2000 CFM):
      a. Pressure Class: Positive 2-inch wg.
      b. Minimum SMACNA Seal Class: C.
      c. SMACNA Leakage Class for Rectangular: 12.
      d. SMACNA Leakage Class for Round and Flat Oval: 12.
   2. Ducts Connected to Constant-Volume Air-Handling Units and Rooftop Units Greater Than 2000 CFM:
      a. Pressure Class: Positive 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6
      d. SMACNA Leakage Class for Round and Flat Oval: 6
   3. 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: 3.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.
   4. Ducts Connected to Equipment Not Listed Above:
      a. Pressure Class: Positive 4-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 3.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.

C. Return Ducts:
   1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, Terminal Units and Rooftop Units (0-2000 CFM):
      a. Pressure Class: Positive or negative 2-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 6.
   2. Ducts Connected to Air-Handling Units and Rooftop Units Greater Than 2000 CFM:
      a. Pressure Class: Positive or negative 3-inch wg.
      b. Minimum SMACNA Seal Class: A.
      c. SMACNA Leakage Class for Rectangular: 6.
      d. SMACNA Leakage Class for Round and Flat Oval: 3.
   3. Ducts Connected to Equipment Not Listed above:
      a. Pressure Class: Positive or negative 4-inch wg.
      b. Minimum SMACNA Seal Class: A.

c. SMACNA Leakage Class for Rectangular: 3.
d. SMACNA Leakage Class for Round and Flat Oval: 3.

D. Exhaust Ducts:
1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
a. Pressure Class: Negative 2-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
2. Ducts Connected to Air-Handling Units:
a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.
3. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:
a. Type 316, stainless-steel sheet.
1) Exposed to View: No. 4 finish.
2) Concealed: No. 2D finish.
b. Pressure Class: Positive or negative **5-**inch wg.
c. Minimum SMACNA Seal Class A, Welded seams and joints.
d. SMACNA Leakage Class 3.
e. Airtight/watertight.
4. Ducts Connected to Equipment Not Listed above:
a. Pressure Class: Positive or negative 3-inch wg.
b. Minimum SMACNA Seal Class: A if negative pressure; A if positive pressure.
c. SMACNA Leakage Class for Rectangular: 6.
d. SMACNA Leakage Class for Round and Flat Oval: 3.

E. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Match duct material.

F. Liner:
1. Supply-Air Ducts: Fibrous glass, Type I, 1 inch thick.
2. Return-Air Ducts: Fibrous glass, Type I, 1 inch thick.
3. Exhaust-Air Ducts: Fibrous glass, Type I, 1 inch thick. (Except for fume hood exhaust)
4. Supply Fan Plenums: Fibrous glass, Type II, 1 inch thick.
5. Return- and Exhaust-Fan Plenums: Flexible elastomeric, 2 inches thick.
6. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.

G. Elbow Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
a. Velocity 1000 fpm or Lower:
1) Mitered Type RE 4 with vanes.
b. Velocity 1000 to 1500 fpm:
1) 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) 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: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. 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.

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 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Manual volume dampers.
2. Combination fire/smoke dampers.
3. Flange connectors.
4. Turning vanes.
5. Duct-mounted access doors.
6. Duct access panel assemblies.
7. Flexible connectors.
8. Duct accessory hardware.

B. Related Requirements:
1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.
1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
   a. Special fittings.
   b. Manual volume damper installations.
   c. Control-damper installations.
   d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   e. Duct security bars.
   f. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 90A and NFPA 90B.

B. 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 shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Air Rite, Inc.
      b. Air Balance; a division of MESTEK, Inc.
      c. Aire Technologies.
      d. American Warming and Ventilation; a Mestek Architectural Group company.
      e. Arrow United Industries.
      f. Cesco Products; a division of MESTEK, Inc.
      g. Greenheck Fan Corporation.
      h. Lloyd Industries, Inc.
      i. McGill AirFlow LLC.
      j. Nailor Industries Inc.
      k. NCA
      l. Pottorff.
      m. Ruskin Company.
      n. Safe Air – Dowco Products.
      o. United Enertech.
      p. Vent Products Co., Inc.
   2. Performance:
      a. 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. Rectangular Dampers:
      a. Frames:
         1) Frame: Hat-shaped, 0.064-inch-thick, galvanized sheet steel.
         2) Mitered and welded corners.
         3) Flanges for attaching to walls and flangeless frames for installing in ducts.
      b. Blades:
         1) Multiple or single blade.
         2) Parallel- or opposed-blade design.
         3) Stiffen damper blades for stability.
         4) Galvanized-steel, 0.064-inch-thick.
   5. Round Dampers:
      a. Frames:
         1) Factory manufactured, 0.034-inch-thick
      b. Blades:
         1) Single blade.
         2) Stiffen damper blade for stability.
         3) Galvanized steel, 0.034-inch thick.

6. Blade Axles: Plated steel.
7. Bearings:
   a. Oil-impregnated bronze.
   b. 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. Stainless Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Warming and Ventilating; a Mestek Architectural Group company.
   b. Arrow United Industries.
   c. Cesco Products; a division of MESTEK, Inc.
   d. Lloyd Industrial, Inc.
   e. McGill AirFlow LLC.
   f. Nailor Industries Inc.
   g. Pottorff.
   h. Ruskin Company.
   i. Safe Air – Dowco Products.
   j. United Enertech.
   k. Vent Products Co., Inc.
2. Performance:
   a. 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. Locking device to hold damper blades in a fixed position without vibration.

C. 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.

D. 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.

E. Damper Regulators:
1. Locking Quadrant Damper Regulators:
   a. Approved Products:
      1) Duro Dyna: KS-385.
      2) Dyn Air: QPS-385.
      3) Elgen Manufacturing: EQR-4.
      4) Ventfabrics: Ventline 555.
      5) Young: No. 1.
2. Concealed Ceiling Damper Regulators:
   a. Approved Products:
      1) Cain.
      2) Duro Dyne.

3) Elgen Manufacturing.
4) Metco Inc.
5) Ventfabrics: 666 Ventlok
6) Young: 301.

3. Dampers above removable ceiling and in Mechanical Rooms shall have locking quadrant on bottom or side of duct. Otherwise, furnish with concealed ceiling damper regulator and cover plate.

2.3 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation
4. Nailor Industries Inc.
5. Ruskin Company

B. Type: Static rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-frpm velocity.

D. Fire Rating: 1-1/2 and 3 hours.

E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

G. Heat-Responsive Device: Electric resettable link and switch package, factory installed, rated.

H. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

I. Blades: Roll-formed, horizontal, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

J. Leakage: Class 1.

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

M. Damper Motors: Two-position action.

N. Comply with NEMA designation, temperature rating, service factor, enclosed type, and efficiency requirements for motors specified in Division 23 Section “Common Motor Requirements for HVAC equipment.”
1. 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.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
7. Electrical Connection: 115 V, single phase, 60 Hz.

2.4 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. DYnAir; a Carlisle Company.
4. Ward Industries; a brand of Hart & Cooley, Inc.

B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.5 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aero-Dyne Sound Control Co
2. CL WARD & Family Inc.
3. Ductmate Industries, Inc.
4. Duro Dyne Inc.
5. DynAir; a Carlisle Company.
6. Elgen Manufacturing.
7. Ward Industries; a brand of Hart & Cooley, Inc.

B. 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. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. 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."

E. Vane Construction:
   1. Single wall.
   2. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.6 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Aire Technologies.
   2. Arrow United Industries.
   3. Cesco Products; a division of MESTEK, Inc.
   4. CL WARD & Family Inc.
   5. Ductmate Industries, Inc.
   6. Duro Dyne Inc.
   7. Elgen Manufacturing.
   8. Flexmaster U.S.A., Inc.
   9. McGill AirFlow LLC.
   10. Ruskin Company.
   11. United Enertech.
   12. Ventfabrics, Inc.
   13. Ward Industries; a brand of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels 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."
   1. Door:
      a. Double wall, rectangular.
      b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      c. 24-gauge-thick galvanized steel or 0.032-inch thick aluminum or 24-gauge-thick stainless steel door panel.
      d. Vision panel.
      e. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
      f. Fabricate doors airtight and suitable for duct pressure class.
   2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
      a. 24-gauge-thick galvanized steel or 0.032-inch-thick aluminum frame.
   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 with outside and inside handles.
      d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.7 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CL WARD & Family Inc.
   2. Ductmate Industries, Inc.
   3. Flame Gard, Inc.

B. Access panels used in cooking applications:
   1. Labeled compliant to NFPA 96 for grease duct access doors.
   2. Labeled in accordance with UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness 16-gauge carbon steel.

D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

F. Minimum Pressure Rating: 10 inches wg positive or negative.

2.8 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Duro Dyne Inc.
4. DynAir; a Carlisle Company.
5. Elgen Manufacturing.
6. Thermaflex
7. Ventfabrics, Inc.
8. Ward Industries; a brand of Hart & Cooley, Inc.

B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall 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 shall 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, 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.

H. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 225 lbf/inch in the warp and 300 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

I. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd.
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

J. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
   1. Minimum Weight: 14 oz./sq. yd.
   2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
   3. Service Temperature: Minus 67 to plus 500 deg F.

K. 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.

2.9 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Flexmaster U.S.A., Inc.
   2. Flex-Tek Group
   3. Hart and Cooley
   4. JP Lamborn Co.
   5. McGill AirFlow LLC
   6. Quietflex
   7. Ward Industries; a brand of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire, fibrous-glass insulation; polyethylene vapor-barrier firm.
   1. Pressure Rating: 6-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 20 plus 200 deg F.
   4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:
   1. Clamps: Nylon strap in sizes 3 through 18 inches, to suit duct size.
   2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.10 DUCT ACCESSORY HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. CL WARD & Family Inc.
   2. Ductmate Industries, Inc.
   3. Duro Dyne Inc.
   4. DYnAir; a Carlisle Company.
   5. Elgen Manufacturing.
   6. Hardcast; a Carlisle Company.

7. Unjited Enertech.
8. Ventfabrics, Inc.
9. Ward Industries; a brand of Hart & Cooley, Inc.

B. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

C. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.11 HE BRANCH TAP

A. Factory-manufactured rectangular-to-round 45 degrees leading tap fabricated of 24 ga zinc-coated lockforming quality steel sheets meeting requirements of ASTM A 653, with G-90 coupling.

B. One inch wide mounting flange with die formed corner clips, pre-punches mounting holes, and adhesive coated gasket.

C. Manual Volume Damper:
1. Single blade, 22 ga minimum.
2. 3/8 inch minimum square rod with brass oil impregnated damper bearings at each end.
3. Heavy duty locking quadrant on 1-1/2 inch high stand-off mountain bracket attached to side of round duct.

2.12 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221, Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

F. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

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 stainless steel accessories in stainless steel ducts.

C. Install backdraft or motorized dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.

E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having 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.

F. Damper Regulators:
   1. Install concealed ceiling damper regulators.
      a. Paint cover plate to match ceiling tile.
      b. Do not install damper regulators for dampers located directly above removable ceilings or in Mechanical Rooms.
   2. Provide each take-off with an adjustable volume damper to balance that branch.
      a. Anchor dampers securely to duct.
      b. Install dampers in main ducts within insulation.
      c. Dampers in branch ducts shall fit against sheet metal walls, bottom and top of duct, and be securely fastened. Cut duct line to allow damper to fit against sheet metal.
      d. Where concealed ceiling damper regulators are installed, provide cover plate.

G. Set dampers to fully open position before testing, adjusting, and balancing.

H. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

I. Install fire and smoke dampers in accordance with UL listing.

J. 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 shall be pressure relief access doors and shall 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. For grease ducts, install at locations and spacing as required by NFPA 96.
   10. Control devices requiring inspection.
   11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. 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.

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5 inches wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Install duct test holes where required for testing and balancing purposes.

Q. 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.

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 233300

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. In-line centrifugal fans.

1.2 SUBMITTALS

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

B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a certified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Acme Engineering & Manufacturing Corporation.
   2. Greenheck Fan Corporation.
   3. Loren Cook Company.
   4. PennBarry.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:
   1. Companion Flanges: For inlet and outlet duct connections.
   2. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.2 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   1. 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.
   2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

B. \Enclosure Type: Totally enclosed, fan cooled.

2.3 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support suspended units from structure using threaded steel rods and elastomeric hangers. Vibration-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Install units with clearances for service and maintenance.

C. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:
1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Modulating, dual and single-duct air terminal units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Certified 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, DUAL AND SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Krueger
   2. Titus
   3. For other products/manufacturers, prior approval is required.

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, Fibrous Glass" 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, 1 percent of nominal airflow at 3-inch wg inlet static pressure.

E. Velocity Sensors: Multipoint array with velocity inlet sensors.

F. 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.
   2. Damper Position: Normally open.

G. Velocity Sensors: Multiport array with velocity sensors.

H. Control Sequence: See Section 230993.11 "Sequence of Operation for HVAC" for control sequences.

2.3 SOURCE QUALITY CONTROL

A. AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.

B. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.

C. 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 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "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 DUCTWORK CONNECTIONS

A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.4 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 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 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.

3.6 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Contractor will engage a certified testing agency to perform tests and inspections.

B. 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.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Square ceiling diffusers.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
   2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers
   1. Products:
      a. Titus TDC
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Krueger
      b. Titus
   3. Material: Steel
   4. Finish: Baked enamel, color selected by Architect.
   5. Face Size: As scheduled.
   6. Face Style: Louvered.
   7. Mounting: Surface or T-bar.
   8. Pattern: Fixed.
   9. Dampers: None.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. 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, as much as practical. 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 233713.13

SECTION 233713.23 - AIR REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fixed face registers and grilles.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
   2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 REGISTERS AND GRILLES

A. Fixed Face Register (Louvered):
   1. Products:
      a. Titus 355
   2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Krueger.
      b. Titus.
   3. Material: Steel or Aluminum.
   4. Finish: Baked enamel, color selected by Architect.
   5. Face Blade Arrangement: Horizontal spaced 1/2” apart.
   6. Core Construction: Integral.
   7. Frame: 1-1/4 inches wide.
   8. Mounting: Surface or T-bar.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. 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, as much as practical. 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 registers and grilles 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 registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

ELECTRICAL TABLE OF CONTENTS

ITEM	SECTION
ELECTRICAL GENERAL PROVISIONS	26 0001
ELECTRICAL DEMOLITION	26 0080
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS	26 0519
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS	26 0526
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS	26 0529
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS	26 0533
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING	26 0544
SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS	26 0548
IDENTIFICATION FOR ELECTRICAL SYSTEMS	26 0553
WIRING DEVICES	26 2726
FUSES	26 2813
DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM	28 3111

SECTION 260001 - ELECTRICAL GENERAL PROVISIONS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification sections, apply to work of this section.

B. Architectural, Structural, Mechanical and other applicable documents also apply to work of this section.

1.2 DESCRIPTION OF WORK:

A. The contract documents indicate the extent of electrical work. Provide all labor, materials, equipment, supervision and service necessary for a complete electrical system as described in divisions 26, 27, and 28.

1.3 RELATED SECTIONS:

A. Other Divisions relating to electrical work apply to the work of this section. See other applicable Divisions including, but not necessarily limited to:

1. Division 1 – General and Supplementary Conditions
2. Division 2 – Existing Conditions
3. Division 3 – Concrete
4. Division 5 – Metals
5. Division 6 – Wood, Plastics, and Composites
6. Division 7 – Thermal and Moisture Protection
7. Division 8 – Openings
8. Division 9 – Finishes
9. Division 21 – Fire Suppression
10. Division 22 – Plumbing
11. Division 23 – Heating Ventilating and Air Conditioning
12. Division 27 – Communications
13. Division 28 – Electronic Safety and Security
14. Division 31 – Earthwork
15. Division 32 – Exterior Improvements
16. Division 33 – Utilities

1.4 INTERPRETATIONS OF DRAWINGS AND SPECIFICATIONS:

A. Prior to bidding the job, submit requests for clarification in writing to the Architect/Engineer prior to issuance of the final addendum.

B. After signing the contract, provide all materials, labor, and equipment to meet the intent, purpose, and function of the contract documents.

C. The following terms used in Division 26, 27, and 28 documents are defined as follows:

1. "Provide" - Means furnish, install, and connect, unless otherwise indicated.
2. "Furnish" - Means purchase new and deliver in operating order to project site.
3. "Install" - Means to physically install the items in-place.

4. "Connect" - Means make final electrical connections for a complete operating piece of equipment. This includes providing conduit, wire, terminations, etc. as applicable.
5. "Or Equivalent" - Means to provide equivalent equipment. Such equipment must be approved by the Engineer prior to bidding.

1.5 EXAMINATION OF SITE:

A. Visit the site and verify existing field conditions prior to submitting bid.

B. All costs arising from site conditions and/or preparation shall be included in the base bid. No additional charges will be allowed due to inadequate site inspection.

1.6 QUALITY ASSURANCE:

A. Perform work in accordance with all governing codes, rules, and regulations including the following minimum codes (latest editions or as otherwise accepted by the Authorities Having Jurisdiction):

1. National Electric Code (NEC)
2. International Building Code (IBC)
3. International Fire Code (IFC)
4. International Mechanical Code (IMC)
5. International Plumbing Code (IPC)
6. International Energy Conservation Code (IECC)
7. American Disability Act (ADA)
8. National Electrical Safety Code (NESC) State Approved Version
9. Local Codes and Ordinances
10. The State Building Board Requirements
11. Utah State Fire Marshal’s Rules R710 Requirements
12. Nation Fire Alarm Code (NFPA 72)
13. Life Safety Code (NFPA 101)
14. University of Utah Requirements

B. Comply with all standards where applicable for equipment and materials including the following minimum standards:

1. Underwriter's Laboratories (UL)
2. American Society for testing Materials (ASTM)
3. Certified Ballast Manufacturers (CBM)
4. Insulated Cable Engineers Association (ICEA)
5. National Electrical Manufacturer's Institute (NEMA)
6. American National Standards Institute (ANSI)
7. Electrical Testing Laboratories (ETL)
8. National Fire Protection Association (NFPA)
9. Institute of Electrical and Electronics Engineers (IEEE)
10. American Institute of Electrical Engineer's Electrical Power
11. Systems and Grounding in Commercial Construction
12. Illuminating Engineers Society of North America (IESNA)
13. National Electrical Safety Code (NESC) - Handbook No. H-30, H-43, H-81, United States of American Standards Association (USAS)
14. Standards for Electrical Safety in the Workplace (NFPA 70E)
15. Standard for Emergency and Standby Power Systems (NFAP 110)
16. Standard for the Installation of Lightning Protection Systems (NFPA 780)
17. EPA Non-road Diesel Emission Standards
18. Electronic Industries Alliance/Telecommunication Industries Association 567/569 (EIA/TIA)

C. Provide new electrical equipment conforming to all requirements as set forth in the above standards. Provide UL labeled equipment where such label is applicable.

D. Comply with all state and local codes and ordinances. When conflicts occur among codes, standards, drawings, and/or specifications, the most stringent requirements shall govern.

E. Obtain all permits, inspections, etc. required by authority having jurisdiction. Include all fees in bid. Provide a certificate of approval to the owner's representative from the inspection authority at completion of the work.

F. Provide only first-class workmanship from competent workers, conforming to the best electrical construction practices.

G. The contractor shall have a current state contracting license applicable to type of work to be performed under this contract.

1.7 SUBMITTALS:

A. Submit in accordance with general provisions.

B. The contractor shall submit complete shop drawings and other required submittals. Incomplete submittals will be returned to the contractor unreviewed. No time extensions or cost increases will be allowed for delays caused by the return of incomplete submittals.

C. Shop Drawings: After the contract is awarded, but prior to manufacture or installation of any equipment, submit eight (8) complete sets of shop drawings. Partially complete sets of shop drawings are not acceptable. Submit all shop drawings in one complete submittal package. Prior to submitting shop drawings, review and certify that they are in compliance with the contract documents; Sign all approved shop drawings. Allow a minimum of two weeks for architect/engineer to review shop drawings. Refer to architectural general provision section for additional requirements.

D. Submit all electrical equipment to Campus Design and Construction and the University Electrical Shop for approval

E. Provide equipment catalog “cut sheets”, brochures and/or drawings which clearly describe the proposed equipment. Include plans, elevations, sections, isometrics, and detailed engineering and dimensional information as applicable including equipment room layouts. Electrical room layouts are required to show all electrical equipment locations for all projects that include electrical rooms. Do not submit catalog sheets which describe several different items in addition to those items to be used, unless all relevant information is clearly identified. Bind each information set in three ring binder or binders of sufficient size or sizes to enclose all information. Organize all information by section. Provide separate tabbed covers for each section of Divisions 26, 27, and 28, indicating section number for each section requiring submittals.

F. Include on front cover of binder or binders the name and location of the project, architect, electrical engineer, general contractor, electrical contractor, subcontractors, supplier/vendor, order number, volume, date, and any other applicable information. Certify that shop drawings are submitted in accordance with the contract documents with a written statement indicating compliance. Submittals will be reviewed and comments produced two times maximum. Additional reviews will be billed at current rates.

1.8 OPERATION AND MAINTENANCE MANUALS:

A. Submit four (4) complete sets of operating instruction and maintenance manuals for all

equipment and materials provided under Divisions 26, 27, and 28.

B. Provide manufacturer's recommended operating and maintenance instructions, cleaning and servicing requirements, serial and model number of each piece of equipment, complete list of replacement parts, performance curves and data, wiring diagrams, warranties, and vendor's name, address, and phone numbers. Do not submit information which describes several different items in addition to those items to be used, unless all relevant information is clearly identified. Assemble all data in completely indexed volume or volumes. Engrave the job title, and name, address, and phone numbers of the contractor on the front cover and on the spine. Incomplete O&M manuals will be returned to the contractor for corrections / additions.

C. Operation and Maintenance Manuals must be electronically-copied data in a self-executable, searchable *.pdf format.

1. Confirm that all data and instruction sheets are marked to indicate the plan symbol, model, number, and options installed for each item of equipment furnished and installed. These data sheets are to be presented as reviewed and approved submittals, or shall be accompanied by such.
2. Confirm that the serial numbers of each item of equipment installed are listed along with the model numbers and plan symbols.
3. Additionally, confirm that the following information is included:
   a. A Table of Contents.
   b. A complete parts list(s) and source of supply for each piece of equipment, marked with model, size, and plan symbol(s).
   c. Copies of the approved submittals for each piece of equipment.
   d. The balance report, when applicable.
   e. Performance curves and capacity data, marked with model and size, in addition to plan, symbols.
   f. Wiring diagrams, marked with model and size, in addition to plan, symbols.
4. The following information is to appear on the front cover of the CD submittal:
   a. “Operation and Maintenance Manual”
   b. Project Name (and volume number, if manual consists of more than one volume)
   c. Project number (the seven-digit University number)
   d. Building name, number, and street address
   e. “University of Utah”
   f. Consultant’s name
   g. Applicable Sub-Consultant’s name
   h. General Contractor’s name
   i. Mechanical Contractor’s name
5. Require contact lists for each item with complete contact information, including addresses and phone numbers.

1.9 RECORD DRAWINGS:

A. Maintain on a daily basis a complete set of "Red-Lined Drawings", reflecting an accurate record of all work including addendums, revisions, and changes. Indicate precise dimensioned locations of all concealed work and equipment, including concealed or embedded conduit, junction boxes, etc. Record all "Red-Lined Drawing" information on a set of full sized prints of the contract drawings.

B. Certify the "Red Lined Drawings" for correctness. Indicate on each drawing the name of the general and electrical contractors with signatures of each representative responsible for the work.

C. The electrical engineering design firm will create record (as-built) drawings from the certified red-lined drawings; however, the general and electrical contractors retain the responsibility for

the accuracy of the record drawings.

D. Provide and permanently mount one set of Record Electrical Drawings in the main electrical room, at completion of the project.

E. Provide and permanently mount one laminated Record One-line Diagram adjacent to main distribution panel(s).

1.10 WARRANTY:

A. Ensure that the electrical system installed under this contract is in proper working order and in compliance with drawings, specifications, and/or authorized changes and is free from electrical defects. Without additional charge, replace or repair, to satisfaction of the owner's representative, except from ordinary wear and tear, any part of the installation which may fail or be determined unacceptable within a period of one (1) year after final acceptance or as otherwise indicated in individual sections, but in no case less than one year. Warranty incandescent and fluorescent lamps only for a period of two months from the date of substantial completion.

B. Provide complete warranty information for each item including beginning of warranty period, duration of warranty, names, addresses, and telephone numbers and procedures for filling a claim and obtaining warranty services. Written warranties and guarantees are to be submitted separately as:

1. Originals bound in a binder clearly identified with the title, “WARRANTIES AND GUARANTEES,” the project name, the project number, and the Contractor’s business name.
2. Electronic documents in *.pdf format.

PART 2 – PRODUCTS

2.1 GENERAL:

A. All materials shall be new and shall bear the manufacturer's name, trade name, and the approved testing laboratory such as the UL label in every case where a standard has been established for that particular material. Used materials are acceptable only if specifically indicated on drawings.

2.2 SUBSTITUTION OF MATERIALS:

A. Provide only specified products or products approved by addendum. Substitutions will be considered if two copies of the proposal is received at the architect's/engineer's office eight (8) working days prior to the bid day. Include in the proposal the specified and proposed catalog numbers of the equipment under consideration and a catalog cut sheet(s) with pictorial and descriptive information. Certify that the equipment proposed is equal to that specified, that it has the same electrical and physical characteristics, compatible dimensions, and meets the functional intent of the contract documents.

B. It is the responsibility of the contractor to make all substituted equipment comply with the intent of the contract documents and bear all cost associated with conflicts arising form the use of substituted equipment.

C. Provide samples if so required by the architect or engineer before or after bid day.

2.3 SPARE PARTS:

A. Provide spare parts as specified in Divisions 26, 27, and 28 sections. Deliver all spare parts to owner's representative prior to substantial completion.

PART 3 – EXECUTION

3.1 GENERAL:

A. Workmanship: Provide only first class workmanship from competent workers. Defective materials or workmanship will not be allowed on the project. Provide competent supervision for the work to be accomplished. Keep same foreman on the job, unless a change is authorized by the engineer.

B. Coordination: Prior to construction, layout electrical work and coordinate work with other trades. Sequence, coordinate, and integrate installation of materials and equipment for efficient flow of the work. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed. Install electrical equipment to facilitate maintenance and repair or replacement of equipment components. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components. Coordinate with all utilities including power, communication, and data installations.

C. Provide cutting, drilling, channeling, etc. only as necessary for proper completion of the work. Do not cut structural members unless authorization is issued in writing by the architect/engineer.

D. Repairs: Repair damage to building, grounds, or utilities as a result of work under this contract at no additional cost to the owner.

E. Dimensioning: Electrical drawings indicate locations for electrical equipment only in their approximate location, unless specifically dimensioned. Do not scale electrical drawings for dimensional information. Refer to architectural drawings and shop drawings where applicable for locations of all electrical equipment. Field verify all dimension on the job site.

F. Provide block-outs, sleeves, demolition work, etc., required for installation of work specified in this division.

G. Standards: Provide electrical installation in accordance with manufacturer's written instructions, applicable requirements of NEC, NEMA standards, and NECA's "Standards of Installation", and in compliance with recognized industry practices to ensure that products fulfill requirements.

H. All workmen doing work of any nature on State of Utah projects must at all times carry their electrician's license with them and show it upon request. The acceptable ratio of apprentice to journeyman electricians on the job is 1:1.

3.2 REQUESTS FOR INFORMATION:

A. When it is clearly apparent that information is not adequately described in the construction documents or when a coordination problem exists, submit a request for information (RFI) through proper contractual channels. The electrical engineering design firm will provide a response through its contractual channel. Although verbal direction may be given to expedite changes, responses are not considered part of the contract documents until a change order has been issued and signed by the Owner or his designated representative. The Contractor shall

bear all costs associated with proceeding on any change order that has not been approved by the Owner or his designated representative.

B. Any damages caused by construction delays due to frivolous RFI's, will be born solely by the Contractor.

3.3 SAFETY PRECAUTIONS:

A. Provide all necessary guards or construction barriers and take all necessary precautions to insure the safety of life and property.

3.4 CLEAN:

A. Clean up all equipment, conduit, fittings, wire, packing cartons, plastic, and other debris that is a direct result of the installation of the work of this division, both during the execution, and at the conclusion, of the project. Keep the site clean and safe during the progress of the work. Clean fixtures, interior and exterior of all equipment, and raceways prior to final acceptance. Vacuum interior of all electrical panels and equipment. Correct any damaged equipment. Touch-up or repaint if necessary.

3.5 TEMPORARY POWER:

A. Make arrangements with the proper institution authority for all temporary electricity.

B. Provide temporary power, complete with metering and wiring for lighting and power outlets for construction tools and equipment. Report the initial meter reading to the owner/institution, or otherwise as may be directed.

C. Service shall be provided with a main disconnect and all 20 ampere receptacles protected by 20 amp GFI, single-pole breakers. No attempt is made herein to specify construction power requirements for equipment in detail. Provide all electrical equipment and wiring as required.

D. As soon as permanent power and metering is available, the temporary power supply shall be disconnected and removed from the project site.

E. All temporary wiring shall meet the requirements of NEC Article 305 and the State Industrial Commission.

3.6 POWER OUTAGES:

A. All power outages required for execution of this work shall occur during non-standard working hours and at the convenience of the owner. Any electrical service interruption will be coordinated at least 7 days in advance of the power shut-off. Include all costs for overtime work in bid. Coordinate all outages and proceed only after receiving authorization from the owner's representative. Keep all outages to an absolute minimum.

3.7 STORAGE AND PROTECTION OF MATERIALS:

A. Provide storage space for storage of materials and apparatus and assume complete responsibility for all losses due to any cause whatsoever. Lost or damaged materials will be replaced at no additional cost to owner. Do not store materials and apparatus in any public thoroughfare or in any area on the site where such storage would constitute a hazard to persons in the vicinity. Protect completed work, work underway, and apparatus against loss or damage.

3.8 EXCAVATING FOR ELECTRICAL WORK:

A. Verification: Prior to excavating, locate and protect existing utilities and other underground work in a manner which will ensure that no damage or service interruption will result from excavating and backfilling. Observe all State and Local codes prior to excavating. Do not disturb walls, footings, and other structural members in any way.

B. Protection: Provide barricades, warning signs, and illumination to protect persons from injury at excavations. Provide temporary coverings and heat as necessary to protect bottoms of excavations from freezing and frost action. Do not install electrical work on frozen excavation bases or subbases.

C. Coordination: Do not excavate for electrical work until the work is ready to proceed without delay.

D. Excavated Materials: Temporarily store excavated materials near excavation in manner which will not interfere with or damage excavation or other work. Dispose of and remove excavated materials which are either in excess of quantity needed for backfilling or do not comply with the requirements for backfill material.

E. Burial Depths: Burial depths must comply with NEC Section 300-5 (or State of Utah requirements, whichever is more stringent), unless noted otherwise on drawings.

F. Excavation Permits: Obtain all shut-down and excavation permits as may be required for proper completion of the work.

3.9 BACKFILL MATERIALS:

A. For buried conduits or cables (other than below slab-on-grade, or concrete-encased), provide 2" thickness of well-graded sand on all sides of conduits or cables.

B. For trench backfill to within 6" of final grade, provide soil material suitable for compacting to required densities.

C. For top 6" of excavation, provide top soil.

D. Backfill excavations in 8" high courses of backfill material, uniformly compacted to the following densities (percent of maximum density, ASTM D 1557), using power-driven hand-operated compaction equipment:

1. Lawn/Landscaped Areas: 85 percent for cohesive soils, 95 percent for cohesionless soils.
2. Paved Areas, other than roadways: 90 percent for cohesive soils, 95 percent for cohesionless soils.

E. Where subsidence is observable at electrical work excavations during project warranty period, remove surface, add backfill material, compact, and replace surface treatment. Restore surface to original condition.

3.10 ROOF PENETRATIONS:

A. Where raceways and/or cables penetrate roofing, provide 26 gauge galvanized iron roof jack, sized to fit tightly to raceway and/or cable for weather-tight seal, and with flange extending a minimum of 9" under roofing on all sides. Seal opening between raceway and roof jack with approved sealant. Coordinate all work with division 7.

3.11 FIRE PENETRATION SEALS:

A. Seal all raceway and/or cable penetrations through fire-rated floors, wall, and ceilings to prevent the spread of smoke, fire, toxic gas or water through the penetration either before, during or after fire. Provide penetration sealants and fittings of ratings to match the rating of the penetrated materials so that the original fire rating of the floor or wall is maintained as required by Article 300-21 of the NEC.

B. Sealant Systems: Provide sealants, wall wraps, partitions, caps, and other accessories complying with UL 1479 (ASTM E-814) from the following where applicable:

1. 3M Fire Barrier Sealing Penetration System
2. Chase Foam Fire Stop System
3. Thomas and Betts Flame Safe Fire Stop System
4. Nelson Fire Stop Products

C. Fittings: Where applicable, provide OZ Type CFSF/I and CAFSF/I fire seal fittings for conduit and cable penetrations through concrete and masonry wall, floor, slabs, and similar structures.

D. Install sealants and fittings in accordance with all manufacturer's written instructions.

3.12 LABELING:

A. Engraved black plastic laminated, with white-core labels, 1/16" thick, shall be permanently attached on both the interior and exterior the following electrical equipment:

1. Branch panels
2. Switchgear
3. Disconnect switches
4. Motor starter and controls junction boxes (power and auxiliary)
5. Push buttons
6. Thermal switches
7. Time switches
8. Motor control centers
9. Transformer
10. Similar equipment.
11. Lighting contactors and associated switches
12. Junction boxes larger than 4x4x1/2.

B. The labels shall have 1/4" high, engraved letters, such as EF-1, AC-1, Panel A, etc.

C. Label for motor starters and/or thermal overload switches shall include heater size and F.L.A.

D. Labels shall be red where serving emergency loads.

3.13 CONCRETE BASES:

A. Housekeeping Pads: Unless otherwise noted, provide 4" high reinforced concrete bases for all floor-mounted or floor-standing electrical equipment, including but not necessarily limited to the following:

1. Transformers
2. Switchgear
3. Motor control centers
4. Generators
5. Battery racks
6. Similar Equipment

B. Extend bases 6" beyond equipment or mounting rails on all sides or as shown on the drawings. Not withstanding this requirement, coordinate with equipment manufacturer, shop drawings, and height of base to ensure compliance with NEC 380-82.

C. Concrete bases: Refer to Section 260551 – Exterior Area Lighting.

D. Transformer Pads: Provide and locate properly sized concrete pads for power company furnished pad mounted transformers in accordance with power company clearance requirements.

3.14 TESTS:

A. Notify engineer prior to all testing specified herein at least three business days prior to testing. Engineer shall observe all tests to insure the proper operation of the electrical system.

3.15 PROJECT FINALIZATION AND START-UP:

A. Upon completion of the work, have each factory representative and/or subcontractor assist in start-up and testing of their respective systems.

B. Have each representative give personal instructions on operating and maintenance of their equipment to the owner's maintenance and/or operation personnel.

C. Have representatives certify each system with a written statement indicating that they have performed start-up and final check out of their respective systems.

3.16 FINAL REVIEW:

A. Have the project foreman accompany their reviewing parties and remove coverplates, panel covers, access panels, etc. as requested, to allow review of the entire electrical system.

END OF SECTION

SECTION 260080 - ELECTRICAL DEMOLITION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-1 Specification Sections, apply to work of this section.

B. This section is a Division 26 General Provisions section, and is part of each Division 26, 27, and 28 sections making reference to electrical demolition.

1.2 SUMMARY:

A. Extent of electrical demolition work is indicated by drawings.

B. Electrical demolition items are shown to give a basic description of the extent of demolition work, but may not be inclusive.

C. Do not assume that the electrical drawings reflect as-built conditions. Visit and observe the project prior to submitting bid and determine extent of electrical demolition work.

1.3 QUALITY ASSURANCE:

A. Standards: Refer to Section 260001 - Electrical General Provisions as applicable.

PART 2 – PRODUCTS - Not Used.

PART 3 – EXECUTION

3.1 GENERAL:

A. Demolition work shall be laid out in advance to eliminate unnecessary cutting, drilling, channeling, etc. Where such cutting, drilling, or channeling becomes necessary, perform with care, use skilled mechanics of the trades involved. Cutting work of other contractors shall be done only with the consent of that contractor. Cutting of structural members is not permitted. Repair damage to building and equipment as a result of electrical demolition work under this contract at no additional cost to owner.

B. Obtain permission from the architect before penetrating any ceiling, floor, and wall surfaces.

3.2 METHODS:

A. Disconnect and remove any/all fixtures, devices, equipment, etc. required for proper completion of the work whether shown or not.

B. Relocate, rewire, and/or reconnect any/all fixtures, devices, equipment, etc. that for any reason obstructs construction.

C. Maintain circuit integrity and continuity of all existing circuits/feeders, and systems that interfere with or are interrupted by remodel work, unless those circuits/feeders are to be abandoned completely. Maintain all circuits and systems in operation during construction. Provide temporary panels, temporary wiring and conduits, etc. as required.

D. Leave all existing fixtures, devices, equipment, etc. in portions of the building not being remodeled, in working condition.

E. Remove and dispose of all raceways, conductors, boxes, devices, equipment, etc. that are not to be reused. Terminate at accessible junction box by providing proper knockout closure, tape conductors, and label as "spare" with circuit no., Zone no., or other characteristic identifying source.

F. Existing raceways may be reused, if in place, where in compliance with the contract documents and the National Electrical Code. Upgrade and/or provide new conduit supports where necessary for all raceways being reused. Insure integrity of existing raceways before re-use.

G. Return to the owner all light fixtures which are to be removed. Dispose of all light fixtures if so directed by owner in accordance with local environmental laws and policies. Those fixtures indicated for re-use shall be thoroughly cleaned, repaired as required, re-lamped, and installed as indicated. When storing fixtures for reuse, store in area and/or provide protective covering that will keep construction dust and materials off fixtures.

H. Completely remove all old concrete housekeeping pads for electrical equipment that has been removed. Where concrete housekeeping pads have been removed, the area shall be grounded down smooth to match adjacent floor surfaces.

I. Completely remove all telephone or data cables which are to be removed back to source or as directed by owner.

J. Disconnect and remove all sound system equipment including speakers, amplifiers, etc. And return to owner. Completely remove and dispose of all associated conduit and wire.

3.3 PATCHING AND REPAIR:

A. Finished Surfaces: The electrical contractor is responsible for patching and repair of all existing interior surfaces pertaining to the installation of work under this Division, unless specifically noted elsewhere in the contract documents. Where patching and repair is necessary, surfaces shall be finished (painted, etc.) to match the adjacent materials, finished, and colors. Requirements of other Divisions such as Division 9 - finishes shall apply.

B. Hard Surfaces: Whenever excavation or trenching is required for the installation of electrical work, it shall be the responsibly of the electrical contractor to make repairs and/or replacements of hard finish surfaces such as concrete, asphalt, etc. Requirements of other Divisions such as Division 2 – Existing Conditions shall apply.

3.4 CONCEALING:

A. All raceways shall be concealed within the ceilings, walls, and floors, except in locations where exposed raceways are specifically permitted, such as equipment rooms and unfinished storage areas.

B. Surface-mounted raceways or systems shall be permitted only where approved by Architect/Engineer.

3.5 DRILLING:

A. The contractor shall provide a method such as X-ray or R-F frequency to determine locations of all structural members prior to drilling through concrete or masonry.

3.6 HAZARDOUS MATERIALS:

A. Materials and devices assumed to contain hazardous materials included:

1. Light fixture ballasts that do not have an attached sticker or label stating “Contains no PCBs” shall be treated as a hazardous material under the “Universal Waste Rule” for lamps and ballasts pursuant to the Code of Federal Regulations, Title 40, Part 261 and 273, and the Utah Administrative Code, Rule R315.2 and Rule R315 and R316 pursuant to State and Federal Laws.
2. Fluorescent light bulbs and tubes are to be treated as containing hazardous materials and handled as Universal Waste (see regulation listed above).

B. Materials and devices assumed to contain hazardous materials are to be disposed of at a facility that is certified by State and Federal Environmental agencies to accept these items for disposal.

C. Materials to be removed from the project site for disposal are to be repackaged in new containers to ensure against damage or breakage.

D. At the end of the Project, the Contractor is to submit two copies each of the “Disposal Manifest” indicating the quantity and type of waste that were delivered to the disposal facility.

3.7 ASBETOS CONTAINING MATERIALS

A. The Owner is responsible for identifying any possible Asbestos containing materials. It is not the contractor’s responsibility to provide abatement or testing services for these materials.

B. The Owner shall provide an ACM report to the Contractor showing known locations of asbestos containing materials. Do not drill or damage materials in these areas prior to abatement.

END OF SECTION

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Building wires and cables rated 2000 V and less.
2. Wires and cables for PV systems rated 2000 V and less.
3. Connectors, splices, and terminations rated 2000 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
2. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

A. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Cerro Wire LLC.
2. Encore Wire Corporation.
3. General Cable Technologies Corporation.
4. Southwire Company.

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. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable used in VFC circuits.

E. Conductors: Copper, complying with NEMA WC 70/ICEA S-95-658.

1. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for [Type THW] [Type THW-2] [Type THHN/THWN-2] [Type XHHW-2] [Type UF] [Type USE] [and] [Type SO].

F. Cable: Comply with NEMA WC 70/ICEA S-95-658 for [armored cable, Type AC] [metal-clad cable, Type MC] [mineral-insulated, metal-sheathed cable, Type MI] [nonmetallic-sheathed cable, Type NM] [Type SE] [Type SO] [and] [Type USE] with ground wire.

1. VFC Cable: Type TC-ER with oversized crosslinked polyethylene insulation, [spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire] [dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires], and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

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

1. 3M Electrical Products.
2. AFC Cable Systems; a part of Atkore International.
3. Hubbell Power Systems, Inc.
4. Ideal Industries, Inc.
5. ILSCO.
6. O-Z/Gedney; a brand of Emerson Industrial Automation.
7. Thomas & Betts Corporation, A Member of the ABB Group.
8. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices 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 application.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 14 AWG and smaller; stranded for No. 12 AWG and larger.

D. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway [Type XHHW-2, single conductors in raceway].

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway [Type XHHW-2, single conductors in raceway].

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway [Type XHHW-2, single conductors in raceway].

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway [Metal-clad cable, Type MC].

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

I. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway [Metal-clad cable, Type MC].

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. VFC Output Circuits: [Type XHHW-2 in metal conduit] [Type TC-ER cable with braided shield] [Type TC-ER cable with dual tape shield].

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes 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.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 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.

   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

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 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors 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. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.

    c. Inspect compression applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.
    f. Insulation-resistance test on each conductor with respect to 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.
    g. Continuity test on each conductor and cable.
    h. Uniform resistance of parallel conductors.

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 230500

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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 grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:

1. Test wells.
2. Ground rods.
3. Ground rings.
4. Grounding arrangements and connections for separately derived systems.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Instructions for periodic testing and inspection of grounding features at test wells grounding connections for separately derived systems based on NFPA 70B.

1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Burndy; Part of Hubbell Electrical Systems.
2. ERICO International Corporation.
3. ILSCO.
4. O-Z/Gedney; a brand of Emerson Industrial Automation.
5. Thomas & Betts Corporation, A Member of the ABB Group.

2.2 SYSTEM DESCRIPTION

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. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 4/0 AWG minimum.

1. Bury at least 24 inches below grade.

C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.

D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

E. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all 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 a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

G. Metallic Fences: Comply with requirements of IEEE C2.

1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 INSTALLATION

A. Grounding Conductors: 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.

B. 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.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
2. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches deep, with cover.

1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. 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 any 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 a disconnect-type connection is required, use a bolted clamp.

F. 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 a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a 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 a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of area or item indicated.

1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24 inches from building's foundation.

J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. 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 a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any 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 according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

B. Related Requirements:

1. Section 260548 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

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. Hangers.
   b. Steel slotted support systems.
   c. Nonmetallic support systems.
   d. Trapeze hangers.
   e. Clamps.
   f. Turnbuckles.
   g. Sockets.
   h. Eye nuts.
   i. Saddles.
   j. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Nonmetallic slotted-channel systems.
4. Equipment supports.
5. 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 Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of trapeze hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which hangers and supports will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Projectors.

B. Seismic Qualification Certificates: For hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Surface-Burning Characteristics: Comply with ASTM E 84; 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 D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.

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

   a. Allied Tube & Conduit; a part of Atkore International.
   b. B-line, an Eaton business.
   c. ERICO International Corporation.
   d. GS Metals Corp.
   e. Thomas & Betts Corporation, A Member of the ABB Group.
   f. Unistrut; Part of Atkore International.
   g. Wesanco, Inc.

2. Material: Galvanized steel.
3. Channel Width: 1-5/8 inches.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
6. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
7. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: 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.

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

1) Hilti, Inc.
2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
3) MKT Fastening, LLC.
4) Simpson Strong-Tie Co., Inc.

2. Mechanical-Expansion Anchors: 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.

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

1) B-line, an Eaton business.
2) Empire Tool and Manufacturing Co., Inc.
3) Hilti, Inc.
4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.

B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other 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 single-bolt conduit clamps using spring friction action for retention in support channel.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.

C. 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 shall be weight of supported components plus 200 lb.

D. 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:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. 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 by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for 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.

3.4 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches 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. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place 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.

3.5 PAINTING

A. Touchup: 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. Touchup: Comply with requirements in architectural specifications for 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 A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

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. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

A. GRC: Galvanized rigid steel conduit.

B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Certificates: For enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. AFC Cable Systems; a part of Atkore International.
2. Allied Tube & Conduit; a part of Atkore International.
3. Republic Conduit.
4. Robroy Industries.
5. Western Tube and Conduit Corporation.

B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. IMC: Comply with ANSI C80.6 and UL 1242.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch, minimum.

F. EMT: Comply with ANSI C80.3 and UL 797.

G. FMC: Comply with UL 1; zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel.
b. Type: Setscrew or compression.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

J. Joint Compound for IMC or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS, TUBING, AND FITTINGS

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

1. Arnco Corporation.
2. CANTEX INC.
3. CertainTeed Corporation.
4. Condux International, Inc.
5. Kraloy.
6. RACO; Hubbell.
7. Thomas & Betts Corporation, A Member of the ABB Group.

B. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ENT: Comply with NEMA TC 13 and UL 1653.

D. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

E. LFNC: Comply with UL 1660.

F. Rigid HDPE: Comply with UL 651A.

G. Continuous HDPE: Comply with UL 651B.

H. Coilable HDPE: Preassembled with conductors or cables, and complying with ASTM D 3485.

I. RTRC: Comply with UL 1684A and NEMA TC 14.

J. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

K. Fittings for LFNC: Comply with UL 514B.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

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

1. B-line, an Eaton business.
2. Hoffman; a brand of Pentair Equipment Protection.

3. Square D.

B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 or Type 3R unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. 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.

D. Wireway Covers: Screw-cover type unless otherwise indicated.

E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.

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

a. Hubbell Incorporated; Wiring Device-Kellems.
b. Panduit Corp.
c. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

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

1. Crouse-Hinds, an Eaton business.
2. EGS/Appleton Electric.
3. Hoffman; a brand of Pentair Equipment Protection.
4. Kraloy.
5. O-Z/Gedney; a brand of Emerson Industrial Automation.
6. RACO; Hubbell.
7. Robroy Industries.

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, round or rectangular.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

M. Gangable boxes are prohibited.

N. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 or Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. NEMA 250, Type 1 or Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

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

   a. Armorcast Products Company.
   b. Carson Industries LLC.
   c. Oldcastle Precast, Inc.
   d. Quazite: Hubbell Power Systems, Inc.

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC.".
7. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC or IMC.
2. Concealed Conduit, Aboveground: GRC, IMC, or EMT.
3. Underground Conduit: RNC, Type EPC-40-PVC.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT or RNC identified for such use.
3. Exposed and Subject to Severe Physical Damage: GRC or IMC. Raceway locations include the following:

a. Loading dock.
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
c. Mechanical rooms.
d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC or IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Install surface raceways only where indicated on Drawings.

F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

E. Arrange stub-ups so curved portions of bends are not visible above finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

H. Support conduit within 12 inchesof enclosures to which attached.

I. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-footintervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 3 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

J. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

L. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inchradius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all 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 raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
   d. Attics: 135 deg F temperature change.

3. 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.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Z. 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.

AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

BB. Locate boxes so that cover or plate will not span different building finishes.

CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

EE. Set metal floor boxes level and flush with finished floor surface.

FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

    a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
    b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

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

    a. Advance Products & Systems, Inc.
    b. CALPICO, Inc.
    c. Metraflex Company (The).
    d. Proco Products, Inc.

2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:

    a. HOLDRITE.

2.4 GROUT

A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Sealant shall have a VOC content of <Insert value> g/L or less.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

   a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
   b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260548 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

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. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic forces required to select seismic restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer.

C. Welding certificates.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: [A] [B] [C] [D] [E] [F].
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [I] [II] [III].

a. Component Importance Factor: 1.5.
b. Component Response Modification Factor: [1.5] [2.5] [3.5] [5.0].
c. Component Amplification Factor: [1.0] [2.5].

3. Design Spectral Response Acceleration at Short Periods (0.2 Second).
4. Design Spectral Response Acceleration at 1.0-Second Period: Insert percentage.

2.2 RESTRAINT CHANNEL BRACINGS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Unistrut; Part of Atkore International.

B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

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

1. Kinetics Noise Control, Inc.
2. Loos & Co., Inc.
3. Vibration Mountings & Controls, Inc.

B. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

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

1. B-line, an Eaton business.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections 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.

2.5 MECHANICAL ANCHOR BOLTS

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

1. B-line, an Eaton business.
2. Hilti, Inc.
3. Kinetics Noise Control, Inc.
4. Mason Industries, Inc.

B. Mechanical Anchor Bolts: 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 required for anchor and as tested according to ASTM E 488.

2.6 ADHESIVE ANCHOR BOLTS

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

1. Hilti, Inc.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.

B. Adhesive Anchor Bolts: 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 E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for 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 Raceways or Cables: Secure raceways and cables 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 caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. 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.

E. 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.

F. Drilled-in 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 the 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 Anchors: 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 Anchors: 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 SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Perform the following 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 postconnection 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.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

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. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels, including arc-flash warning labels.
8. Miscellaneous identification products.

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 electrical identification products.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 LABELS

A. Self-Adhesive Labels:

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. Ideal Industries, Inc.
b. Panduit Corp.

2. Vinyl, thermal, transfer-printed, 3-mil- thick, clear background with black lettering, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, wiring devices or other equipment unless otherwise indicated.

a. Nominal Size: sized for the application and/or equipment.

3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 TAPES AND STENCILS:

A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

B. 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, provide products by one of the following:

a. Carlton Industries, LP.
b. Seton Identification Products.

C. Underground-Line Warning Tape

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

    a. Brady Corporation.
    b. Ideal Industries, Inc.
    c. Marking Services, Inc.
    d. Seton Identification Products.

2. Tape:

    a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. Color and Printing:

    a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
    b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
    c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

4. Tag: Type ID:

    a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    b. Width: 3 inches.
    c. Overall Thickness: 5 mils.
    d. Foil Core Thickness: 0.35 mil.
    e. Weight: 28 lb/1000 sq. ft..
    f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.

D. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.4 Signs/Tags

A. Laminated Acrylic or Melamine Plastic Signs/Tags:

1. Engraved legend with 5/8” minimum lettering height.
2. Thickness:

    a. For signs up to 20 sq. inches, minimum 1/16-inch-.
    b. For signs larger than 20 sq. inches, 1/8 inch thick.
    c. Lamicoid nameplates shall be three-ply. Letters shall be formed by engraving into the outer colored ply, exposing the white or black center-ply.
    d. Self-adhesive.

3. Color:

a. Master Nameplate – black face with white lettering
b. Normal Power – black face with white lettering
c. Emergency Power – red face with white lettering
d. UPS Power – blue face with white lettering
e. Medium Voltage – yellow face with black lettering

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

a. Brady Corporation.
b. Carlton Industries, LP.
c. emedco.
d. Marking Services, Inc.

2.5 CABLE TIES

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

1. Ideal Industries, Inc.
2. Marking Services, Inc.
3. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black, except where used for color-coding.

C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
4. Color: Black.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.

1. Minimum Width: 3/16 inch.
2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F.
5. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. 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).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

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 INSTALLATION

A. 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.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. 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.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

G. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

H. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

I. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

1. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.

    a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
    b. Colors for 208/120-V Circuits:

        1) Phase A: Black.
        2) Phase B: Red.
        3) Phase C: Blue.
        4) Neutral A: White with black strip.
        5) Neutral B: White with red strip.
        6) Neutral C: White with blue strip.
        7) Equipment Ground: Green

    c. Colors for 480/277-V Circuits:

        1) Phase A: Brown.
        2) Phase B: Orange.
        3) Phase C: Yellow.
        4) Neutral A: Gray with black strip.
        5) Neutral B: Gray with red strip.
        6) Neutral C: Gray with blue strip.
        7) Equipment Ground: Green

    d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

B. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.

C. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.

D. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

    1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
    2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
    3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

    1. Limit use of underground-line warning tape to direct-buried cables.
    2. Install underground-line warning tape for direct-buried cables and cables in raceways.

F. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall 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.

G. Arc Flash Warning Labeling: Self-adhesive thermal transfer vinyl labels.

1. Comply with NFPA 70E and ANSI Z535.4.
2. Comply with Section 260574 "Overcurrent Protective Device Arc-Flash Study" requirements for arc-flash warning labels.

H. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

I. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine plastic label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment To Be Labeled:

a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a self-adhesive, engraved, laminated acrylic or melamine label.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchgear.
e. Switchboards.
f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Substations.
h. Emergency system boxes and enclosures.
i. Motor-control centers.
j. Enclosed switches.
k. Enclosed circuit breakers.
l. Enclosed controllers.
m. Variable-speed controllers.
n. Push-button stations.
o. Power-transfer equipment.
p. Contactors.
q. Remote-controlled switches, dimmer modules, and control devices.
r. Battery-inverter units.

s. Battery racks.
t. Power-generating units.
u. Monitoring and control equipment.
v. UPS equipment.

END OF SECTION 260553

SECTION 262726 - WIRING DEVICES

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. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Isolated-ground receptacles.
4. Tamper-resistant receptacles.
5. Weather-resistant receptacles.
6. Snap switches and wall-box dimmers.
7. Solid-state fan speed controls.
8. Wall-switch and exterior occupancy sensors.
9. Communications outlets.
10. Pendant cord-connector devices.
11. Cord and plug sets.
12. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

E. TVSS: Transient voltage surge suppressor.

F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Eaton (Arrow Hart).
2. Hubbell Incorporated; Wiring Device-Kellems.
3. Leviton Manufacturing Co., Inc.
4. Pass & Seymour/Legrand (Pass & Seymour).

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

B. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

1. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Description: Labeled shall comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.4 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.

B. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:

1. Description:

a. Comply with NEMA WD 1, NEMA WD 6 Configuration L5-20R, and UL 498.
b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA Configurations as required by equipment being served. Coordinate exact device with equipment.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.

4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.7 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single pole, two-pole, three-way and four-way

C. Pilot-Light Switches, 20 A:

1. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors.

F. Key-Operated, Single-Pole, Double-Throw, Momentary-Contact, Center-off Switches: 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

2.9 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Smooth, high-impact thermoplastic.
3. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.10 FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular or Round, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

E. Voice and Data Communication Outlet: Two modular, keyed, color-coded, RJ-45 jacks for UTP cable complying with requirements in Section 271500 "Communications Horizontal Cabling."

2.11 POKE-THROUGH ASSEMBLIES

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand (Pass & Seymour).
3. Thomas & Betts Corporation, A Member of the ABB Group.
4. Wiremold / Legrand.

B. Description:

1. Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Flush type with services indicated complying with requirements in Section 271500 "Communications Horizontal Cabling."
4. Size: Selected to fit nominal 4-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 4-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables that comply with requirements in Section 271500 "Communications Horizontal Cabling."

2.12 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Power System: Red.
3. TVSS Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:

   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use printed P-Touch style labels on face of plate, and durable wire markers or tags inside outlet boxes.

END OF SECTION 262726

SECTION 260800 – COMMISSIONING OF ELECTRICAL SYSTEMS

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.
B. Section 019113 – General Commissioning Requirements

1.2 DEFINITION

A. Commissioning is a quality focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained as specified in the Owner's Project Requirements (OPR).

1.3 SCOPE

A. This Section shall form the basis of the construction phase commissioning process. The Commissioning Agent (CxA) shall add, modify, and refine the commissioning procedure to suit field conditions and manufacturers' equipment, incorporate test data and procedure results, and provide detailed scheduling for all commissioning tasks.
B. The following building systems are within the Commissioning Scope of Work:

1. Please review Sections 220800, 230800, and 260800.

1.4 QUALITY ASSURANCE

A. The commissioning process shall be conducted in accordance with the following reference documents.

1. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 202, Commissioning Process for Building and Systems
2. State of Utah – Department of Administrative Services Division of Facilities Construction and Management (DFCM) Design Requirements, High Performance Building Standards
3. National Environmental Balancing Bureau (NEBB) – Procedural Standards for Whole Building Systems Technical Commissioning
4. Building Commissioning Association (BCxA) – New Construction Building Commissioning Best Practice
5. AABC Commissioning Group Guidelines (ACG) – ACG Commissioning Guideline

1.5 COMMISSONED SYSTEMS

A. Commissioning shall be performed on the following systems and components.
B. Commissioning will be performed on the following systems and components.

1. Electrical as related to Sections 22 and 23.

PART 2: PRODUCTS (NOT APPLICABLE)

PART 3: EXECUTION

3.1 GENERAL

A. The Subcontractors shall be responsible for performing procedures presented in specification and contract drawings. Members of the designated Commissioning Team shall witness various portions of the commissioning process. Responsibilities for these activities are listed in the following paragraphs. Commissioning Team members shall sign-off on appropriate sections after verifying installation, operation, or documentation. Documentation shall be dated and

initialed by field engineer or technician performing the work. Final sign-off shall be by the Owner and Commissioning Agent.

B. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

3.2 PREFUNCTIONAL CHECKLISTS

A. Review and Complete Prefunctional Checklists in accordance with Section 01 91 13 and 26 08 00.
B. Contractor's Commissioning Coordinator shall verify completion of all items, sign and return the checklist to the Commissioning Authority as an indication of final completion with all installation criteria as specified in the Project Contract Documents
C. The initial Prefunctional Checklists will be provided in the Commissioning Plan. The final checklists may be modifications of the initial checklists, and checklists may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
D. A separate completed checklist shall be submitted for each system and item of equipment within the commissioning scope of work, as specified in 01 91 13.
E. The Systems Readiness Checklists do not represent all of the contract documents for the associated equipment. Completion of the items on this checklist does not release the contractor from requirements specified elsewhere
F. Lighting and lighting control pre-functional checks include but are not limited to:

    1. Ensure all labeling is affixed and accurate.
    2. Verify quantity, type and location of fixtures.
    3. Verify type and location of switches.
    4. Check sensor placement is adequate for required duty.
    5. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
    6. Ensure all circuits for the loads are energized and ready for testing.

3.3 STARTUP PLAN

A. The Contractor shall provide a Startup Plan, which shall include the following:

    1. Prefunctional Checklists – provided by CxA and completed by the Contractor except as noted below.
    2. Startup and testing procedures and data forms, in accordance with the project specifications, for all equipment and systems within the commissioning scope of work

B. Within 20 working days of Product Submittal approval, submit the Startup Plan with blank forms for CxA review.
C. Submit the completed Startup Plan prior to functional performance testing. When it is necessary to begin functional performance testing on a system (or systems) before the readiness of other systems can be documented, it may be acceptable to provide preliminary submittals of the Startup Plan that have been completed only for the system(s) that are ready for testing.
D. Lighting and Lighting Controls Start-up Procedures: Follow the manufacturer's written procedures and the following as a minimum:

    1. Verify operation of lighting controls (dimming, photo-control, regular switching).
    2. Check loads on all breakers to ensure that the breaker is properly sized.
    3. Enter all schedules per occupant's direction.
    4. For Operator Interfaces: Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
    5. Output all specified reports for review and approval.
    6. Verify the alarm printing and logging is functional and per requirements.
    7. Validate all interfaces with other systems on a point by point basis.

3.4 FUNCTIONAL PERFORMANCE TESTING

A. The Functional Performance Test (FPT) Procedures shall be developed, performed, and demonstrated in accordance with Section 01 91 13.
B. At a minimum, the electrical, lighting control contractors are required to participate in developing, performing, and demonstrating the indicated FPTs.
C. The initial FPTs will be developed after review of the submittals. The final FPTs may be modifications of the initial FPTs, and FPTs may be added; modifications and additions to be made by the Commissioning Authority after equipment submittals have been accepted.
D. The Contractor's Commissioning Coordinator shall coordinate the subcontractors, with the Commissioning Authority's input, in developing, performing, and demonstrating the Working FPT.
E. Functional testing of the daylighting and lighting control system shall, at a minimum, consist of the following:

1. Spot check the lighting systems Start-up and ensure that the all lamps are operational, and fixtures are clean.
2. Check all occupancy sensor placement and test reliability of activation/deactivation.
3. Test photocells for functionality and accuracy.
4. Check all switches to ensure proper operation and circuiting.
5. Individually check all lighting panel schedules to ensure that room numbers and areas are correctly listed, and they are programmed per the Owner's direction.
6. Spot check lighting levels to ensure compliance with IES for the respective occupancy.
7. Test operation of circuits by changing system Date and Time to cause various circuits to switch modes. For rooms with occupancy sensors, validate the circuit energizes with occupancy in the space after the lights have been swept off. Test warning flicker prior to off sweep. Test cleaning and shed features.
8. Check schedules and lighting levels in all modes. Coordinate with Owner/Occupant for settings.
9. For exterior fixtures, simulate night mode to validate function. Measure and record light level to ensure they meet the requirements and are generally provide adequate security. Check for excessive light level fluctuations or dark spots

F. **TRENDING**

1. Trending points shall be outlined in the Procedural Standards as delivered by the CxA in the commissioning plan.
2. The network lighting controls contractor shall trend the system in their software for a minimum of four (4) weeks. If the contractor is unable to do four weeks of trending in the system then the contractor shall reimburse the Owner for CxA expenses to install temporary trending loggers.

G. **TRAINING**

1. The CxA shall be invited to all electrical training sessions by the General Contractor.
2. The training shall not commence until the system has been commissioned and proven ready for training.
3. The contractor shall schedule and coordinate training sessions for the Owner's staff for each system. Training shall be in a classroom setting with the appropriate schematics, handouts, and visual/audio training aids on-site with equipment.
4. The Commissioning Authority shall review agendas, which shall be submitted at least four weeks before training, and shall audit the training sessions**.** The agenda shall include but not limited to operational setpoints, runtime schedules, general operation and maintenance requirements, time and location for the training. Agendas shall conform to the Syllabus section in ASHRAE 0-2013-Appendix P and LEED v4 – EA – "Enhanced Commissioning".
5. The training program shall include the following:

a. Emergency instructions and procedures
b. Operation instructions and procedures
c. Troubleshooting procedures
d. Maintenance and inspection procedures
e. Repair procedures
f. Upkeep of the systems manual and associated maintenance documentation logs

6. Evaluations shall be done of the training system by the attendees. The evaluations shall reflect ASHRAE 0-2013-Appenix P Evaluation Form.

   a. If the Evaluations from the training average rises above 2 (based on 1 being very well trained and 5 not at all trained) then the training shall recommence. All cost for the re-training shall be solely born by the contractor training including any reimbursment to the Owner for the CxA, the Owners Operational Staff, and any other cost born by the owner for failure to comply with requirements.

7. The contractor shall provide a schedule for training times and dates. The schedule shall include location, who is training, traineers contact information,
8. The appropriate installing contractors shall provide training on all the major systems per specifications, including peculiarities specific to this project.
9. The equipment vendors shall provide training on the specifics of each major equipment item including philosophy, troubleshooting, and repair techniques.
10. The automatic control vendor shall provide training on the control system per their specification section.
11. The contractor shall furnish a final video DVD set, above the owners requirements as defined elsewhere, to the CxA for their use and ownership and review. Included in those DVDs shall be the sign-in sheet for each training.

END OF SECTION

SECTION 262813 - FUSES

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. Cartridge fuses rated 600 V ac and less for use in the following:

   a. Control circuits.
   b. Panelboards.
   c. Switchboards.
   d. Enclosed controllers.
   e. Enclosed switches.

2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.
5. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," Section 017823 "Operation and Maintenance Data," include the following:

1. Current-limitation curves for fuses with current-limiting characteristics.
2. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
3. Coordination charts and tables and related data.

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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann, an Eaton business.
2. Littelfuse, Inc.

B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting, time delay.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting, time delay.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
7. Type T: 600-V, zero- to 800-A rating, 200 kAIC, very fast acting, time delay.

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. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.

3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Service Entrance: Class L, fast acting Class L, time delay Class RK1, fast acting Class RK1, time delay Class J, fast acting Class J, time delay Class T, fast acting.
2. Feeders: Class L, fast acting Class L, time delay Class RK1, fast acting Class RK1, time delay Class RK5, fast acting Class RK5, time delay Class J, fast acting Class J, time delay.
3. Motor Branch Circuits: Class RK1 Class RK5 Class CC, motor duty, time delay.
4. Large Motor Branch (601-4000 A): Class L, time delay.
5. Power Electronics Circuits: Class J, high speed Class T, fast acting.
6. Other Branch Circuits: Class RK1, time delay Class RK5, time delay Class J, fast acting Class J, time delay Class CC, fast acting.
7. Control Transformer Circuits: Class CC, time delay, control transformer duty.
8. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner.

3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Nonsystem smoke detectors.
6. Heat detectors.
7. Notification appliances.
8. Device guards.
9. Firefighters' two-way telephone communication service.
10. Firefighters' smoke-control station.
11. Magnetic door holders.
12. Remote annunciator.
13. Graphic annunciator.
14. Addressable interface device.
15. Digital alarm communicator transmitter.
16. Radio alarm transmitter.
17. Network communications.
18. System printer.

B. Related Requirements:

1. Section 280513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

F. VESDA: Very Early Smoke-Detection Apparatus.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.
    d. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III minimum.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.
g. Record copy of site-specific software.
h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.

4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.
j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.8 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 by.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

B. Automatic sensitivity control of certain smoke detectors.

C. All components provided shall be listed for use with the selected system.

D. 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 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Fire-extinguishing system operation (Ansul).

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.

7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
8. Recall elevators to primary or alternate recall floors.
9. Activate elevator power shunt trip.
10. Activate emergency lighting control.
11. Activate emergency shutoffs for gas and fuel supplies.
12. Record events in the system memory.
13. Record events by the system printer.
14. Indicate device in alarm on the graphic annunciator.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Elevator shunt-trip supervision.
3. User disabling of zones or individual devices.
4. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
2. Record the event on system printer.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.
5. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 MANUFACTURER

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

1. Gamewell - FCI by Honeywell.

2.5 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

    a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
    b. Include a real-time clock for time annotation of events on the event recorder and printer.
    c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
    d. The FACP shall be listed for connection to a central-station signaling system service.
    e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 40 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

C. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Serial Interfaces:

    a. One dedicated RS 485 port for central-station/remote station operation using point ID DACT.
    b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
    c. One USB port for PC configuration.

D. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

E. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

F. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

   a. Elevator lobby detectors except the lobby detector on the designated floor.
   b. Smoke detector in elevator machine room.
   c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

G. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

H. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

J. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.6 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.7 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type for building standard detectors and four-wire type for residential space detectors.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

C. Photoelectric Smoke Detectors with Sounder Base (Residential Spaces):

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).
    f. Provide local alarm signal for space where detector is installed.

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.8 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.9 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
3. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
4. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
5. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.10 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-(25-mm-) high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
3. Flashing shall be in a temporal pattern, synchronized with other units.
4. Strobe Leads: Factory connected to screw terminals.
5. Mounting Faceplate: Factory finished, white.

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.

2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.12 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report

telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.15 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A in NFPA 72.
5. HVAC: Locate detectors not closer than 60 inches ((1520 mm)) from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways shall be installed in EMT.

B. Junction box covers shall be painted red.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
3. Smoke dampers in air ducts of designated HVAC duct systems.
4. Magnetically held-open doors.
5. Electronically locked doors and access gates.
6. Alarm-initiating connection to elevator recall system and components.
7. Alarm-initiating connection to activate emergency lighting control.
8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
9. Supervisory connections at valve supervisory switches.
10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
11. Supervisory connections at elevator shunt-trip breaker.
12. Data communication circuits for connection to building management system.
13. Data communication circuits for connection to mass notification system.
14. Supervisory connections at fire-extinguisher locations.
15. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
16. Supervisory connections at fire-pump engine control panel.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

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.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111