PART 1 GENERAL

1.1 GENERAL

A. Prior to submitting a proposal, the Design-Build Project Proposers must carefully examine these instructions contained herein and satisfy themselves as to the conditions with which they (each Project Proposer) must comply and the conditions affecting award of the Proposal Agreement. These instructions form part of the Contract Documents and will have the same force as any other Contract Document.

B. Design-Build Project Proposers must be aware of the requirements of codes referenced in the instructions and in the Contract Documents. Project Proposers may access codes and laws through publications or through the internet.

C. Proposals must be addressed as directed in the Division 1 for Invitation to Submit Proposal.

1.2 DESIGN-BUILD SCOPE

A. As a minimum the engineering design shall include, but not be limited to, the following documentation:
   1. Fire Protection
      a. Hydraulic calculations.
      b. Piping layout.

1.3 REFERENCES

A. The publications listed below form a minimum part of this specification to the extent referenced. The current editions of the publications are referred to in the text by the basic designation only.
   1. ASTM A 880 - Criteria for Use in Evaluation of Testing Laboratories and Organizations for Examination and Inspection of Steel, Stainless Steel, and Related Alloys
   2. ASTM C 1077 Laboratories Testing Concrete and Concrete Aggregates for Use In Construction and Criteria for Laboratory Evaluation
   3. ASTM D 3666 (Rev. A) - Evaluating and Qualifying Agencies Testing and Inspecting Bituminous Paving Materials
   4. ASTM D 3740 - Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
   5. ASTM E 329 - Evaluation of Testing and Inspection Agencies as Used in Construction
   6. ASTM E 543 (Rev. A) - Determining the Qualification of Non-Destructive Testing Agencies
   7. ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers
   8. AWS – American Welding Society
   9. SMACNA – Sheet Metal and Air Conditioning Design Builders National association
   10. ACI – American Concrete Institute
   11. AABC – American Air Balance Council
   12. ASPE – American Society of Plumbing Engineers
   13. NETA – International Electrical Test and Acceptance Association
   14. IEEE – Institute of Electrical and Electronic Engineers
   15. NFPA – National Fire Protection Association
   16. All other standards as referenced throughout this set of specification
1.4 REGULATORY REQUIREMENTS

A. General:
   1. All applicable Federal, State and local requirements will govern the construction and completion of the Work; all must be current enforced editions.

B. Copies of Regulations:
   1. Copies of the applicable regulations and codes, Federal, State and local to be retained at site to be available for reference by parties who have a reasonable need.

C. Enforcement:
   1. References in the Agreement Documents to "code" or to "building code" not otherwise identified will mean the foregoing specified codes, together with the additions, changes, amendments and interpretations adopted by the enforcing agency, and in effect on the date the Agreement is executed.
   2. Nothing on the Agreement Documents will be interpreted as requiring or permitting work that is contrary to these rules, regulations and codes.
   3. Where other codes or standards are referenced in the Agreement Documents, the affected work must meet or exceed the applicable requirements of such codes and standards.
   4. The code, specification or standard referred to will have full force and effect as though printed in the Agreement Documents, except as modified.
   5. Where the Agreement Documents call for or describe materials, work quality or construction of a better quality, higher standard or larger size than is required by said laws, codes, rules and regulations, the provisions of the Agreement Documents will take precedence over said laws, codes, rules and regulations.

D. Other Applicable Laws and Regulations:
   1. Applicable Federal, State, and local laws, and the rules and regulations of governing utility districts and the various other authorities having jurisdiction over the construction and completion, including the latest rules and regulations of the State Labor Code, will apply to the Agreement throughout, and they will be deemed to be included in the Agreement the same as though printed in the Agreement Documents.
   2. If laws, ordinances, rules, regulations or orders of public agency having jurisdiction require work to be inspected, tested or approved by some authority other than the Owner or Design-Builder, the Design-Builder must give required notices and make arrangements, deliver to the Owner’s Representative the certificates of inspection, test, or approval of such public agency, and pay costs therefore unless otherwise provided in the Agreement Documents.

1.5 CONFLICTING REQUIREMENTS

A. General:
   1. If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to Owner’s Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels:
   1. The quantity or quality level shown or specified must be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate,
1.6 COMPETENCE OF PROPOSERS

A. License: No Project Proposer may propose on work of a kind for which Project Proposer is not properly licensed, and any such proposal received will be rejected. The Proposal must contain the Design-Build Entity's Contractor's license number, date of expiration, and signature to a statement that representations of the Proposal with respect to Project Proposer's license are made under penalty of perjury.

1. If Project Proposer is a joint venture, each individual member within the joint venture submitting the Proposal will be subject to the above requirements with respect to Contractor's individual licensure. Additionally, the joint venture must have a valid license as a “Joint Venture” in the State where the project is located.

B. Design Consultant/Sub-Consultant Licenses: No Project Proposer may propose on work of a kind for which Project Proposer is not properly licensed by the appropriate License Boards, and any such Proposal received will be rejected. Proposals must contain registration numbers, dates of expiration, and signatures to a statement that representations of the proposal with respect to the professional and business licenses are made under penalty of perjury.

1.7 EXAMINATION OF PROPOSAL DOCUMENTS AND PROJECT SITE

A. Project Proposers Responsibility: Project Proposer must carefully examine the site of the Work and the Request for Proposal package. By submitting a Proposal, Project Proposer acknowledges that Project Proposer understands the character, quality and quantity of site conditions or obstacles to be encountered insofar as this information is reasonably ascertainable from an inspection of the site, including all exploratory work done by the General Contractor, as well as from information presented in the Request for Proposal and information available to the Project Proposer.

B. Site Investigations: Project Proposers must perform their own site investigations at their own expense. Damage to existing utilities must be repaired at the Project Proposer’s expense. To avoid conflict with the work of other Project Proposers, as well as other contractors, arrangements for site investigations must be made through the Owner’s Representative.

C. Responsibility for Utilities: Project Proposer will be responsible at its sole cost for any and all work, expense or special precautions caused or required by existing or proximity of existing utilities shown or indicated on or in the RFP documents and encountered in performing the Work, including, and without limitation thereon, repair of damage and performing hand or exploratory excavation required. Project Proposer is cautioned that such utilities may include communication cables or electrical cables (which may be high voltage), and ducts enclosing such cables, and when working or excavating in the vicinity thereof, special precautions to be observed at Project Proposers cost. All such cables and their enclosure ducts will be exposed by careful hand excavation so as not to damage ducts or cables, nor cause injury to persons. Suitable warning signs, barricades and safety devices must be erected, as necessary or required.

D. Failure by Project Proposer to acquaint itself with available information will not relieve Project Proposer from responsibility for properly estimating the difficulty or cost of successfully performing the Work.
1.8 PROPOSAL QUESTIONS

A. RFI’s and Responses: Project Proposers are encouraged to submit questions. Questions must be submitted in writing, by email (preferred), delivery service, or mail to Owner’s Representative.

1. Written questions may be submitted at any time, but must be submitted no later than seven (7) calendar days at 4:00 PM prior to bid closing date. The Project Proposer must allow a minimum of three (3) business days for response by the Owner’s Representative. No responses will be provided within 72 hours of the bid closing date and time.

2. To expedite responses, Project Proposers are requested to provide their questions via email, with questions detailed in an Excel spreadsheet with the following headings: Date, Subject, Specification Section/Paragraph or Drawing Sheet Number, Question (formatted sizes of cells unimportant – please make them legible).

B. Proposal Interviews: The Owner’s Representative will conduct Proposal Interviews to confirm information provided in Project Proposals submitted by the Project Proposers. This may also be another opportunity for Owner’s Representative to request additional clarification.

1.9 SUBMITTAL PROCEDURES

A. General:

1. Submittals may be forwarded entirely via electronic means.

2. Partial submittals are not acceptable, and will be considered non-responsive, and will be returned without review.

3. Submittals not required by the Agreement Documents may not be reviewed and may be discarded.

4. The specific content and format requirements for the standard submittals are detailed herein and in the individual Specification Sections. The electronic form will be compiled in the most current form of Adobe Acrobat, Release 9.0 or newer, or Bluebeam Revu, Release 10.0 or newer. The electronic file will be bookmarked according to its Table of Contents, but will contain no less than the book marking identification in descending order of section, system, subsystem, equipment, component, etc., where applicable. The goal is to make the submittals both manageable and user friendly for the Owner’s use.

5. Drawing submittals must be in Computer-Aided Design (CAD) format, AutoCAD 2013. or newer, or Revit 2013 or newer.

6. Prior to the implementation of the design work and prior to the formal submittal process, provide a list and cut sheets of all major mechanical and electrical equipment to the Owner’s Representative for review and approval along with the preliminary system calculations that together will drive the mechanical and electrical design and layout.

B. Coordination:

1. Coordinate preparation and processing of submittals with performance of construction activities.

2. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.

3. Coordinate multidiscipline design phase submittals and construction documents prepared the design professionals of record.

4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
C. Submittals Schedule:
   1. Coordinate with Division 1 requirements for Project Management and Coordination for list of submittals and time requirements for scheduled performance of related construction activities.
   2. Submit all Basis of Design submittals together for all disciplines and prior to the start of any construction activity. Subsequent Construction Document submittals can be submitted in phases prior to construction activity related to that phase.

D. Processing Time:
   1. Allow enough time for submittal review, including time for resubmittals, per the following. Time for review will commence on receipt of submittal. No extension of the Agreement Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
   2. Initial Review: Allow at least twenty (20) working days for initial review of each submittal. Allow an additional ten (10) days of time if coordination with subsequent submittals is required from the receipt of the subsequent submittal. Construction Manager will advise Design-Builder when a submittal being processed must be delayed for coordination.
   3. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
   4. Re-submittal Review: Allow ten (10) working days for review of each resubmittal.

E. Identification:
   1. Place a permanent label or title block on each submittal for identification.
   2. Indicate name of firm or entity that prepared each submittal on label or title block.
   3. Provide a space on label or beside title block to record Design-Builder’s review and approval markings and action taken by the Owner’s Representative.
   4. Include the following information on label for processing and recording action taken:
      a. Project name.
      b. Date.
      c. Name and address of Design-Builder.
      d. Name and address of subcontractor, including design professionals for design phase submittals.
      e. Name and address of supplier.
      f. Name of manufacturer.
      g. Submittal number or other unique identifier, including revision identifier. Submittal number must use Performance Specification Section number followed by a decimal point and then a sequential number (e.g., 211000.01). Resubmittals must include an alphabetic suffix after another decimal point (e.g., 211000.01.A).
      h. Number and title of appropriate Performance Specification Section.
      i. Drawing number and detail references, as appropriate.
      j. Location(s) where product is to be installed, as appropriate.
      k. Other necessary identification.

F. Deviations:
   1. Highlight, encircle, or otherwise specifically identify deviations from the Agreement Documents on submittals.

G. Copies:
   1. Action Submittals:
      a. General: Submit three (3) copies to Owner’s Representative. The Owner’s Representative will return two (2) copies.
      b. Samples: Submit three (3) full sets. The Owner’s Representative will return two (2) sets.
c. Operation and Maintenance Manuals: Submit two (2) copies to Owner’s Representative.
d. Project Record Documents: Submit two (2) copies to Owner’s Representative.
e. Demonstration and Training: Submit two (2) copies to Owner’s Representative.

H. Transmittal:
1. Package each submittal individually and appropriately for transmittal and handling.
   Transmit each submittal using a transmittal form.
2. Transmittal Form: Include the following information:
   a. Project name.
   b. Date.
   c. Destination (To:).
   d. Source (From:).
   e. Names of subcontractor, manufacturer, and supplier.
   f. Category and type of submittal.
   g. Submittal purpose and description.
   h. Performance Specification Section number and title.
   i. Drawing number and detail references, as appropriate.
   j. Transmittal number, numbered consecutively.
   k. Submittal and transmittal distribution record.
   l. Remarks.
   m. Signature of transmitter.
3. On an attached separate sheet, prepared on Design-Builder’s letterhead, record relevant information, requests for data, revisions other than those requested on previous submittals, and deviations from requirements in the Agreement Documents, including minor variations and limitations. Include same label information as related submittal.

I. Resubmittals:
1. Make resubmittals in same form and number of copies as initial submittal.
2. Note date and content of previous submittal.
3. Note date and content of revision in label or title block and clearly indicate extent of revision.
4. Resubmit submittals until they are marked with the Owner’s Representative’s approval notation.

J. Distribution:
1. Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers and authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

K. Record Documents: Retain a final copy of all submittals as a Project Record Document.

1.10 SUBMITTAL CLASSIFICATIONS

A. General:
1. Submittals are classified as follows:
   a. Project Proposal submittals. For requirements for these submittals, refer to the Proposal Requirements.
   b. Basis of Design Submittals.
   d. Construction Submittals.
   e. Project Closeout Submittals.
   f. LEED Submittals.
   g. Commissioning Submittals.
1.11 CONSTRUCTION DOCUMENTS DESIGN PHASE SUBMITTALS

A. General:
1. Submit these items during the period of preparation of the Construction Documents.
2. For the general requirements for these Submittals, refer to the Performance Criteria.
3. Organize these submittals in accordance with the Performance Specification, using the same title numbers and titles.
4. Submittals in this Phase are as follows:
   a. Action Submittals:
      1) Basis of Design. In addition to the Requirements indicated in the Performance Criteria, provide annotated Performance Criteria and Concept drawings.
      2) 50% Construction Documents.
      3) 100% Construction Documents.
   b. Information Submittals: Manufacturer’s Certificates, Product Certifications.

1.12 CONSTRUCTION PHASE SUBMITTALS

A. General:
1. Prepare and submit Submittals required for the project conditions and design by individual Performance Specification Sections.
2. For the general requirements for these Submittals, refer to the Performance Criteria.
3. Provide submittals to Owner’s Representative for review and approval prior to fabrication, purchasing and installation.

B. Action Submittals:
1. Action Submittals include Samples, Schedules, and Applications for Payment, Subcontracts List, and others as applicable to the Project.
2. Mechanical/Electrical equipment and systems submittals for those systems to be commissioned for review by Commissioning Authority.
3. Items submitted as substitutions or as “equal” to listed manufacturer(s).

C. Informational Submittals:
1. Prepare and submit Informational Submittals required by Performance Specification Sections.
2. Informational Submittals Include Quality Assurance Submittals, Schedules, Applications for Payment, Insurance Certificates and Bonds, Construction Photographs and Videotapes, and others as applicable to the Project.
3. Design-Builder’s subcontractor Design professionals of Record will review and stamp all construction submittals for conformance with the construction documents prepared and signed by the Registered Design Professionals.
4. Shop drawings and equipment submittals not directly related to commissioning or required for review by commissioning authority.
5. Retain copies of all submittals at job site trailer.
6. Certificates and Certifications: Provide a notarized statement that includes signature of entity responsible for preparing certification. Certificates and certifications must be signed by an officer or other individual authorized to sign documents on behalf of that entity.
7. Test and Inspection Reports.
1.13 REQUIREMENTS FOR EACH SUBMITTAL CATEGORY

A. Product Schedule or List:
   1. As required in individual Performance Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
      a. Type of product. Include unique identifier for each product.
      b. Number and name of room or space.
      c. Location within room or space.

B. Product Data:
   1. Collect information into a single submittal for each element of construction and type of product or equipment.
   2. If information must be specially prepared for submittal because standard printed data are not suitable for use, submit as Shop Drawings, not as Product Data.
   3. Mark each copy of each submittal to show which products and options are applicable.
   4. Include the following information, as applicable:
      a. Manufacturer's written recommendations.
      b. Manufacturer's product specifications.
      c. Manufacturer's installation instructions.
      d. Standard color charts.
      e. Manufacturer's catalog cuts.
      f. Wiring diagrams showing factory-installed wiring.
      g. Printed performance curves.
      h. Operational range diagrams.
      i. Standard product operation and maintenance manuals.
      j. Compliance with specified referenced standards.
      k. Testing by recognized testing agency.
      l. Application of testing agency labels and seals.
      m. Notation of coordination requirements.
   5. Submit Product Data before or concurrent with Samples for Initial Selection.

C. Manufacturer Certificates:
   1. Prepare written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.

D. Shop Drawings:
   1. Prepare project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.
   2. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
      a. Dimensions.
      b. Identification of products.
      c. Fabrication and installation drawings.
      d. Roughing-in and setting diagrams.
      e. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring.
      f. Shop work manufacturing instructions.
      g. Templates and patterns.
      h. Equipment schedules.
      i. Design calculations.
      j. Compliance with specified standards.
      k. Notation of coordination requirements.
I. Notation of dimensions established by field measurement.

m. Relationship to adjoining construction clearly required.

n. Seal and signature of professional engineer if specified.

o. Wiring Diagrams: Differentiate between manufacturer-installed and field-installed wiring.

3. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at minimum 8-1/2 by 11 inches but no larger than 30” by 42”.

E. Samples:
   1. Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.
   2. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
   3. Identification: Attach label on unexposed side of Samples that includes the following:
      a. Generic description of Sample.
      b. Product name and name of manufacturer.
      c. Sample source.
      d. Number and title of appropriate Performance Specification Section.

4. Disposal: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.
   a. If approved by Owner’s Representative, certain Samples may be incorporated into the Work. Such Samples must be in an undamaged condition at time of use.
   b. Samples not incorporated into the Work, or otherwise designated as Owner’s Representative’s property, are the property of Design-Build.

5. Samples for Verification:
   a. Submit full-size units or Samples of size required, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; and components used for independent testing and inspection.
   b. Number of Samples: Submit three sets of Samples. Owner’s Representative will retain one Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a Project Record Sample.
      1) Submit a single Sample where assembly details, workmanship, fabrication techniques, connections, operation, and other similar characteristics are to be demonstrated.
      2) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

F. Subcontract List:
   1. Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:
      a. Name, address, and telephone number of entity performing subcontract or supplying products.
      b. Number and title of related Specification Section(s) covered by subcontract.
      c. Drawing number and detail references, as appropriate, covered by subcontract.
G. Qualification Data:
   1. Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, names and addresses of project architects and owners, and other information specified.

H. Welding Certificates:
   1. Prepare written certification that welding procedures and personnel comply with requirements in the Agreement Documents. Submit record of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) on AWS forms. Include names of firms and personnel certified.

I. Installer Certificates:
   1. Prepare written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Agreement Documents and, where required, is authorized by manufacturer for this specific Project.

J. Product Certificates:
   1. Prepare written statements on manufacturer's letterhead certifying that product complies with requirements in the Agreement Documents.

K. Material Certificates:
   1. Prepare written statements on manufacturer's letterhead certifying that material complies with requirements in the Agreement Documents.

L. Material Test Reports:
   1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Agreement Documents.

M. Product Test Reports:
   1. Prepare written reports indicating current product produced by manufacturer complies with requirements in the Agreement Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

N. Research/Evaluation Reports:
   1. Prepare written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:
      a. Name of evaluation organization.
      b. Date of evaluation.
      c. Time period when report is in effect.
      d. Product and manufacturers' names.
      e. Description of product.
      f. Test procedures and results.
      g. Limitations of use.

O. Schedule of Tests and Inspections:
   1. Provide scope for each test and inspection and calendar schedule to the Owner's Representative. Provide minimum 72 hours' notice to Owner's Representative prior to each test and inspection. Owner's Representative may, at their discretion, witness such testing.
P. Preconstruction Test Reports:
   1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with Performance Specifications in the Agreement Documents.

Q. Compatibility Test Reports:
   1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.

R. Field Test Reports:
   1. Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Agreement Documents.

S. Maintenance Data:
   1. Prepare written and graphic instructions and procedures for operation and normal maintenance of products and equipment.

T. Design Data:
   1. Prepare written and graphic information, including, but not limited to, performance and Design Requirements, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and Design Requirements and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.

U. Manufacturer's Instructions:
   1. Prepare written or published information that documents manufacturer's recommendations, guidelines, and procedures for installing or operating a product or equipment. Include name of product and name, address, and telephone number of manufacturer. Include the following, as applicable:
      a. Preparation of substrates.
      b. Required substrate tolerances.
      c. Sequence of installation or erection.
      d. Required installation tolerances.
      e. Required adjustments.
      f. Recommendations for cleaning and protection.

V. Manufacturer's Field Reports:
   1. Prepare written information documenting factory-authorized service representative's tests and inspections. Include the following, as applicable:
      a. Name, address, and telephone number of factory-authorized service representative making report.
      b. Statement on condition of substrates and their acceptability for installation of product.
      c. Statement that products at Project site comply with requirements.
      d. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
      e. Results of operational and other tests and a statement of whether observed performance complies with requirements.
      f. Statement whether conditions, products, and installation will affect warranty.
      g. Other required items required in individual Performance Specification Sections.
W. Construction Photographs and Digital Recordings (DVD’s):
1. Provide record photographs and or digital videos of construction, particularly concealed Work.
2. Obtain and transfer copyright usage rights from photographer to the Owner for unlimited reproduction of photographic documentation.
3. Digital Images:
   a. Provide images in uncompressed TIFF format or JPEG, produced by a digital camera with minimum sensor size of 4.0 megapixels, and at an image resolution of not less than 1600 by 1200 pixels.
   b. Submit digital images exactly as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software. Date and Time: Include date and time in filename for each image.
4. Digital Video Format:
   a. Provide high-quality color recording in DVD format. Quality must be adequate to create photographic prints to be made from individual frames.
5. General:
   a. Take photographs using the maximum range of depth of field, and that are in focus, to clearly show the Work. Photographs with blurry or out-of-focus areas will not be accepted. Maintain key plan with each set of construction photographs that identifies each photographic location.
6. Periodic Construction Photographs: Take a minimum of 25 digital photographs weekly, with timing each month adjusted to coincide with the cutoff date associated with each Application for Payment. Select vantage points to show status of construction and progress since last photographs were taken.

X. Regulatory Agency:
1. Submit licenses, permits, certifications, proof of fee payments for all regulatory agencies, including but not limited to Occupational Safety & Health Administration (OSHA), Air Pollution Control District, Electric Utility, Gas Utility, Public Works Department, etc.

1.14 DESIGN-BUILDER’S REVIEW

A. General:
1. Review each submittal and check for coordination with other Work of the Agreement and for compliance with the Agreement Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Owner’s Representative.

B. Approval Stamp:
1. Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Design-BUILDER’s approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Agreement Documents.
2. The Design-BUILDERS’ Subcontractor California licensed design professionals must review and stamp all Construction submittals. Review for conformance to Construction Documents prepared by the registered design professionals of record for the Project.

1.15 OWNER’S REPRESENTATIVE ACTION

A. General:
1. Where action is required by Owner’s Representative, Owner’s Representative will not review submittals that do not bear Design-BUILDER’s approval stamp and will return them without action.
B. Action Submittals:
   1. Owner’s Representative will review each submittal, make marks to indicate corrections or modifications required, and return it to the Design-Builder.

C. Informational Submittals:
   1. Owner’s Representative will review each submittal and may return it to the Design-Builder stamped appropriately with comments.

1.16 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) DESCRIPTION

A. Establish and maintain a Quality Assurance/Quality Control (QA/QC) program as described in this section and coordinate with the Commissioning program. The QA/QC program must cover construction operations on-site and off-site and must be keyed to the proposed construction sequence and serve as the foundation on which the Commissioning Plan will be built and executed for the mechanical and electrical systems.

B. The process of assuring quality and compliance will take place in two ways. QA/QC must implement a program to monitor, verify, and accept the work during the construction installation, especially the equipment and the system components. The QA/QC program will coordinate with the Commissioning of Work and dovetail the monitoring and requirements for systems and equipment identified under both programs. The Commissioning program will plan, monitor, verify, and accept the operation and the performance of the equipment and systems. In particular, the operation and performance of the mechanical and electrical systems will only be available for verification and acceptance upon the successful execution of the QC/QA program with regard to their installation.

1.17 QA/QC REQUIREMENTS

A. QA/QC Program Requirements - The QA/QC program consists of a QA/QC Organization, a Quality Control (QC) Plan, conducting QA/QC meetings on site, performing submittal review, ensuring testing is performed, and preparing QC certifications and documentation necessary to provide materials, equipment, workmanship, fabrication, construction and operations which comply with the requirements of this Agreement. In addition this Section consists of the coordination of the QA/QC program with the Commissioning program.

1.18 QA/QC DEFINITIONS

A. Quality Assurance Services:
   1. Activities, actions, and procedures performed at a level above Quality Control to assure the work performed has in effect a quality control procedure and process performed by those doing the Work to guard against defects and deficiencies and assure that proposed construction will comply with requirements. Includes submittals, certifications, and other actions to assure that the proposed products and services will meet the Agreement requirements. Services do not include Agreement enforcement activities performed by the Owner.

B. Quality Control Services:
   1. Tests, inspections, procedures, and related actions at the level where the work is performed, during and after execution of the Work, to evaluate that actual products and completed construction comply with all Agreement requirements.

C. Mockups:
   1. Full-size, physical assemblies that are constructed on-site. Mockups are used to verify selections made under sample submittals, to demonstrate aesthetic effects and, where
indicated, qualities of materials and execution, and to review construction, coordination, testing, or operation; they are not Samples. Approved mockups establish the standard by which the Work will be judged.

D. Laboratory Mockups:
1. Full-size, physical assemblies that are constructed at a testing facility to verify performance characteristics.

E. Preconstruction Testing:
1. Tests and inspections that are performed specifically for Design-Build Package before products and materials are incorporated into the Work to verify performance or compliance with specified criteria.

F. Product Testing:
1. Tests and inspections that are performed by a Nationally Recognized Testing Laboratory (NRTL), a National Voluntary Laboratory Accreditation Program (NVLAP), or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.

G. Source Quality Control Testing:
1. Tests and inspections that are performed at the source, i.e., Plant, mill, factory, or shop.

H. Field Quality Control Testing:
1. Tests and inspections that are performed on-site for installation of the Work and for completed Work.

I. Testing Agency:
1. An entity engaged by the Owner’s Representative to perform specific tests, inspections, or both. Testing laboratory will mean the same as testing agency. The testing agency will be under the control of the Owner’s Representative at the Owner’s discretion.

J. Installer/Applicator/Erector:
1. Design-Build or another entity engaged by Design-Build as an employee, Subcontractor, or Sub-subcontractor experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated whose work has resulted in construction with a record of successful in-service performance.
2. Using a term such as “carpentry” does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as “carpenter.” It also does not imply that requirements specified apply exclusively to trades people of the corresponding generic name.

K. Experienced:
1. When used with an entity, "experienced" means having successfully completed a minimum of five previous projects similar in size and scope; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

L. Manufacturer Qualifications:
1. A firm experienced in manufacturing products or systems similar to those indicated and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
M. Fabricator Qualifications:
   1. A firm experienced in producing products similar to those indicated and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.

N. Professional Architect/Engineer Qualifications:
   1. A professional Architect/Engineer who is legally qualified and licensed to practice in the State where the project is located and who is experienced in providing Architecture and Engineering services of the kind indicated. Architect/Engineering services are defined as those performed for installations of the system, assembly, or product that are similar to those indicated in material, design, and extent.

O. Specialists:
   1. Certain sections of the Specifications require that specific construction activities will be performed by entities that are recognized experts in those operations. Specialists must satisfy qualification requirements indicated and must be engaged for the activities indicated.
   2. Requirement for specialists must not supersede building codes and regulations governing the Work.

P. Testing Agency Qualifications:
   1. An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to America Society for Testing of Materials (ASTM) E 548; and with additional qualifications specified in individual Sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
   2. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
   3. NVLAP: A testing agency accredited according to National Institute of Standards and Technology’s (NIST) NVLAP.

Q. Factory-Authorized Service Representative Qualifications:
   1. An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer’s products that are similar in material, design, and extent to those indicated.

R. Preconstruction Testing:
   1. Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods.

1.19 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) ON INSTALLATION

A. Monitoring - Monitor quality control over suppliers, manufacturers, products, services, site conditions and workmanship to produce work of the specified quality.

B. Compliance - Comply fully with manufacturers’ instructions including each step in sequence and comply fully with the Agreement documents inclusive of the entirety of the intent of the Design Criteria.

C. Conflicts - Should manufacturers’ instructions conflict with the Agreement Documents, request clarification from Owner’s Representative before proceeding.
D. Standards:
   1. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, code, or specified requirements indicate higher standards or more precise workmanship.
   2. Perform Work by persons qualified to produce workmanship of specified quality.

E. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, code, or specified requirements indicate higher standards or more precise workmanship.

F. Coordination of all above-ceiling work is mandatory prior to any installation. Documentation of such coordination will be required prior to applicable installation taking place in the specific area concerned.

1.20 QA/QC SUBMITTALS

A. Quality Assurance/Quality Control (QA/QC) Plan: Submit a QA/QC Plan for the Owner’s Representative’s approval within thirty (30) days prior to commencement of construction.

B. Schedule of Tests and Inspections:
   1. Prepare in tabular form and include the following, as applicable:
      a. Specification Section number and title.
      b. Description of test and inspection.
      c. Identification of applicable standards.
      d. Identification of test and inspection methods.
      e. Number of tests and inspections required.
      f. Time schedule or time span for tests and inspections.
      g. Entity responsible for performing tests and inspections.
      h. Requirements for obtaining samples.
      i. Unique characteristics of each quality control service.

C. Reports:
   1. Prepare and submit certified written reports that include the following:
      a. Date of issue.
      b. Name, address, and telephone number of testing agency.
      c. Dates and locations of samples and tests or inspections.
      d. Names of individuals making tests and inspections.
      e. Description of the Work and test and inspection method.
      f. Identification of product and Specification Section.
      g. Complete test or inspection data.
      h. Test and inspection results and an interpretation of test results.
      i. Record of temperature and weather conditions at time of sample taken and testing and inspecting.
      j. Comments or professional opinion on whether tested or inspected Work complies with the Agreement Document requirements.
      k. Recommendations on retesting and reinspecting.

D. Permits, Licenses, and Certificates:
   1. For Owner’s records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.
E. Testing Agency Responsibilities:
   1. Submit a certified written report of each test, inspection, and similar quality-assurance service to the Owner’s Representative, with copy to Design-Builder. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Agreement Documents.

1.21 QA/QC PLAN

A. Requirements: Provide for approval by the Owner’s Representative, a QA/QC Plan that covers both on-site and off-site Work, and includes the following:
   1. A chart showing the QA/QC organizational structure and its relationship to the production side of the organization.
   2. Names and qualifications, in resume format, for each person in the QA/QC organization.
   3. Duties, responsibilities and authorities of each person in the QA/QC organization.
   4. Documentation procedures, including proposed report formats for all reports required herein.
   5. A letter signed by an officer of the firm appointing the QA/QC Manager and stating that he/she is responsible for managing and implementing the QA/QC program as described herein, and that the QA/QC Manager reports to an officer of the firm, someone other than Design-Builder’s Project Manager. Include in this letter the QA/QC Manager’s authority to direct the stopping, removal and replacement of non-conforming Work.
   6. Procedures for reviewing, approving and managing submittals. Provide the name(s) of the person(s) in the QA/QC organization authorized to review and certify submittals prior to approval.
   7. A Testing Plan and Log that includes the tests required, referenced by the specification paragraph number requiring the test, test procedures, the frequency, schedule activity number and the person responsible for each test.
   8. Procedures to identify, record, track and complete rework items, including schedule activity numbers.
   9. A listing of outside organizations such as, architectural and consulting engineering firms that will be employed by Design-Builder and a description of the services and resumes of personnel these firms will provide.
   10. A list of the definable features of work. A definable feature of work is a task that is separate and distinct from other tasks and requires separate control requirements. As a minimum, unless otherwise approved by the Owner’s Representative, consider each section of the specifications as a definable feature of work. However, there may be more than one definable feature of work in each section of the specifications.
   11. A personnel matrix showing, for each section of the specification, who will review and approve submittals, who will perform and document the various phases of control, and who will perform and document the testing.
   12. Provide procedures describing mandatory above ceiling coordination prior to the execution of any above ceiling work.

B. Preliminary Work Authorized Prior to Approval: The only work that is authorized to proceed prior to the approval of the QA/QC Plan is mobilization of storage and office trailers and surveying, the preparation of excavation shoring systems, and removal of hazardous materials. Design-Builder must not proceed on other activities without written approval from the Owner’s Representative.

C. Approval: Approval of the QA/QC Plan is required before the start of construction. The Owner’s Representative reserves the right to require changes in the QA/QC Plan and operations as necessary to ensure the specified quality of Work. The Owner’s Representative reserves the right to interview any member of the QA/QC organization at any time in order to verify his/her submitted qualifications.
D. Notification of Changes: Submit written notification to the Owner’s Representative of any proposed change, including changes in the QA/QC organization personnel, a minimum of seven (7) days prior to a proposed change. Design-Builder must receive Owner approval prior to implementing such proposed changes.

1.22 QA/QC PLAN MEETING

A. Prior to submission of the QA/QC Plan, meet with Owner’s Representative to discuss the QA/QC Plan requirements of this Agreement. The purpose of this meeting is to develop a mutual understanding of the QA/QC Plan requirements prior to plan development and submission.

1.23 QA/QC COORDINATION AND MUTUAL UNDERSTANDING MEETING

A. After submission of the QA/QC Plan, but prior to the start of construction, meet with Owner’s Representative to discuss the QA/QC program required by this Agreement. The purpose of this meeting is to develop a mutual understanding of the QA/QC details, including forms to be used for documentation, administration for on-site and off-site Work, and the coordination of Design-Builder's management, production and QA/QC personnel. As a minimum, Design-Builder’s personnel required to attend must include the project manager, project superintendent, QA/QC Manager, and QA/QC specialists. Minutes of the meeting must be prepared by the QA/QC Manager and signed by both Design-Builder and Owner’s Representative.

1.24 QA/QC DOCUMENTATION

A. Maintain current and complete records of on-site and off-site QA/QC program operations and activities.
   2. Design-Builder Quality Control Report: Reports are required for each day that Work is performed and for every seven (7) consecutive days of no-work and on the last day of a no-work period. Account for each day throughout the life of the Agreement. The reporting of Work must be identified by terminology and activity codes consistent with the construction schedule. Design-Builder Quality Control Reports must be prepared, signed and dated by the QA/QC Manager and must contain the following information:
      a. Identify the control phase (Preparatory, Initial, and Follow-up) and the definable feature of work.
      b. Results of the Preparatory Phase meetings held including the location of the definable feature of work and a list of personnel present at the meeting. Indicate in the report that for this definable feature of work, the drawings and specifications have been reviewed, submittals have been approved, materials comply with approved submittals, materials are stored properly, preliminary work was done correctly, the testing plan has been reviewed, and work methods and schedule have been discussed.
      c. Results of the Initial Phase meetings held including the location of the definable feature of work and a list of personnel present at the meeting. Indicate in the report that for this definable feature of work the preliminary work was done correctly, samples have been prepared and approved, the workmanship is satisfactory, test results are acceptable, work is in compliance with the Agreement requirements, and the required testing has been performed and include a list of who performed the tests.
      d. Results of the Follow-up Phase inspections held including the location of the definable feature of work. Indicate if the report for this definable feature of Work that the work complies with the Agreement requirements as approved in the Initial Phase,
and that required testing has been performed and include a list of who performed the tests.

   e. Results of the three Phases of Control for off-site work, if applicable, including actions taken.

   f. List the rework items identified, but not corrected by close of business.

   g. List the rework items corrected from the rework items list along with the corrective action taken.

   h. Include a "remarks" section in this report which must contain pertinent information including directions received, quality control problem areas, deviations from the QA/QC Plan, construction deficiencies encountered, QA/QC meetings held, acknowledgement that as-built drawings have been updated, corrective direction given by the QC Organization and corrective action taken by Design-Build.

   i. Design-Build Quality Control Report certification.

3. Reports from the QC Specialist(s): Reports are required for each day that Work is performed in their area of responsibility. QC specialist reports must include the same documentation requirements as Design-Build Quality Control Report for their area of responsibility. QC specialist reports must be prepared, signed and dated by the QC specialists and must be attached to Design-Build Quality Control Report prepared for the same day.

4. Testing Plan and Log: As tests are performed, the QA/QC Manager must record on the "Testing Plan and Log" the date the test was conducted, the date the test results were forwarded to IOR, remarks and acknowledgement that an accredited or approved testing laboratory was used. Attach a current updated copy of the "Testing Plan and Log" to the last daily Design-Build Quality Control Report of each month.

5. Rework Items List: The QA/QC Manager must maintain a list of work that does not comply with the Agreement requirements, identifying what items need to be reworked, the date the item was originally discovered, and the date the item was corrected. Attach the current copy of the "Design-Build Rework Items List" to the last daily Design-Build Quality Control Report of each month. Design-Build will be responsible for including on this list items needing rework including those identified by the Owner’s Representative.

6. Record Drawings: The QA/QC Manager is required to review the Record Drawings to ensure that the drawings are kept current on a daily basis and marked to show precise locations of items, or any deviations, which have been made from the Construction Drawings. The QA/QC Manager, or QC Specialist assigned to an area of responsibility, must initial each deviation and each revision. Upon completion of Work, the QA/QC Manager must furnish a certificate attesting to the accuracy of the Record Drawings and verification by the IOR prior to submission to Owner’s Representative.

7. Report Forms:

   a. The reporting format must contain the following information:

      1) Design-Build Daily Report
      2) Design-Build Quality Control Report and Separate Continuation Sheets
      3) Testing Plan and Log
      4) Rework Items List
      5) Construction Methods Form
      6) QA/QC Manager’s Preparatory Phase Check-off Report

   b. Report forms must be transmitted via a method acceptable to Owner’s Representative. All original documents, reports, completed forms, etc. must be forwarded to the Owner’s Representative.

1.25 REPAIR AND PROTECTION

A. General:

   1. Repair and protection are Design-Build's responsibility, regardless of the assignment of responsibility for quality control services.
2. On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes. Protect construction exposed by or for quality control service activities.

3. Provide materials and comply with installation requirements specified in other Specification Sections. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.

1.26 OPERATION AND MAINTENANCE MANUALS (O&M) REQUIREMENTS

A. Standard Operation and Maintenance (O&M) Manuals.

1. The specific content and format requirements for the standard O&M manuals are detailed herein and in the individual Specifications. The O&M Manuals will be submitted in both hard copy and electronic form. The electronic form will be compiled in the most current form of Adobe Acrobat, Release 9.0 or newer, or Bluebeam Revu, Release 10.0 or newer. The electronic file will be bookmarked according to its Table of Contents, but will contain no less than the book marking identification in descending order of section, system, subsystem, equipment, component, etc., where applicable. The goal is to make the manuals both manageable and user friendly for the Owner’s use.

2. Design-Build Design Team Contribution. The Design-Build will include, in the beginning of each O&M manual, a separate section describing the systems, including:
   a. The Basis of Design narrative prepared by the Design-Build, updated to as-built status by the Design-Build.
   b. Simplified, professionally-drawn, single-line system diagrams on 8-1/2” x 11” or 11” x 17” sheets. These must include, but not limited to, systems and major pieces of equipment such as chillers, boilers, piping systems, electrical systems, ductwork systems, and controls systems.

3. State Review and Approval. Prior to completion, the Owner’s Representative will review the O&M Manuals, documentation, and redline as-builts to verify compliance with the Performance Criteria. The Owner’s Representative will communicate deficiencies in the manuals to the Design-Build. Upon a successful review of the corrections, the Owner’s Representative recommends approval and acceptance of these sections of the O&M manuals. The Owner’s Representative also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated.

1.27 WARRANTIES

A. Warranties shall be provided for specific products, equipment and work as identified in Individual Specifications Sections.

B. Form of Warranty: Written warranties, except manufacturer’s standard printed warranties, must be on the Design-Build’s, Subcontractor’s, material supplier, or manufacturer’s own letterhead, addressed to the Owner. All warranties must be submitted in duplicate, in a suitable format, and modified as approved to suit the conditions pertaining to the warranty.

C. Bind warranties in commercial quality 8-1/2” x 11” binders, with hardback, cleanable, plastic covers.

D. Label cover of each binder with typed or printed title "WARRANTIES", with title of Project, name, address, and telephone number of Design-Build; and name of responsible principal.

E. Table of Contents: Neatly typed, in the sequence of the Table of Contents, with each item identified with the number and title of the specification section in which specified, and the name of Product or work item.
F. Separate each warranty with index tab sheets keyed to the Table of Contents listing. Provide full information, using separate typed sheets as necessary. List subcontractor, supplier, and manufacturer, with name, address, and telephone number of responsible principal.

G. Obtain warranties, executed in duplicate by responsible subcontractor, suppliers, and manufacturers, within ten days after completion of the applicable item of work. Except for items put into use with Owner's permission, leave date of beginning of time of warranty until the date of final acceptance or occupancy by the Owner.

H. All warranties must be signed by both the General Design-Builder and the appropriate subcontractor.

I. For equipment or component parts of equipment put into service during construction with Owner's permission, submit documents within ten days after acceptance.

1.28 TRAINING AND DEMONSTRATION SUBMITTALS

A. Instruction Program:
   1. Submit two copies of outline of instructional program for demonstration and training, including: the agenda for the training; a schedule of proposed dates and times; length of instruction time for each section of training, and instructors' names for each training module. Include learning objective and outline for each training module. Each training submittal must be provided a minimum of three weeks before the proposed training date.
   2. At completion of training, submit two complete training manual(s) in both paper and electronic format for the Owner's use. Electronic format to be word searchable.

B. Qualification Data:
   1. For facilitator, instructor, and videographer.

C. Attendance Record:
   1. For each training module, submit list of participants and length of instruction time.
   2. Complete the Training Record form included for each training session conducted. Submit to the Owner within seven (7) calendar days of each session being completed.

D. Evaluations:
   1. For each participant and for each training module, submit results and documentation of performance-based test.

E. Demonstration and Training Interactive DVDs:
   1. Submit two copies within seven (7) calendar days of end of each training module.
   2. Identification: On each copy, provide an applied label with the following information:
      a. Name of Project.
      b. Name and address of videographer.
      c. Name of Construction Manager.
      d. Name of Design-Builder.
      e. Date DVD was recorded.
      f. Description of vantage point, indicating location, direction (by compass point), and elevation or story of construction.
   3. Transcript: Prepared on 8-1/2” by 11” paper, punched and bound in heavy-duty, 3-ring, vinyl-covered binders. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding DVD. Include name of Project and date of DVD on each page. Include copy of relevant DVD in plastic sleeve.
F. Training Planning, Agenda, and Record Forms:
   1. Forms follow on subsequent pages.
      a. Overall Staff Training and Orientation Plan (one page).
      b. Training and Orientation Agenda (two pages).
      c. Staff Training and Orientation Record (one page).

1.29 TRAINING QUALITY ASSURANCE

A. Facilitator Qualifications:
   1. A firm or individual experienced in training or educating maintenance personnel in a
      training program similar in content and extent and whose work has resulted in training or
      education with a record of successful learning performance.

B. Instructor Qualifications:
   1. A factory-authorized service representative experienced in operation and maintenance
      procedures and training.

C. Videographer Qualifications:
   1. A videographer who is experienced digitally recording construction projects.

D. Pre-Instruction Conference:
   1. Conduct conference to review methods and procedures related to anticipated
      demonstration and training including, but not limited to, the following:
      a. Inspect and discuss locations and other facilities required for instruction.
      b. Review and finalize instruction schedule and verify availability of educational
         materials, instructors’ personnel, audiovisual equipment, and facilities needed to
         avoid delays.
      c. Review required content of instruction.
      d. For instruction that must occur outside, review weather and forecasted weather
         conditions and procedures to follow if conditions are unfavorable.

1.30 INSTRUCTION PROGRAM

A. Program Structure:
   1. Develop an instruction program that includes individual training modules for each system
      and equipment not part of a system, as required by individual Specification Sections.

B. Training Modules:
   1. Develop a learning objective and teaching outline for each module. Include a description
      of specific skills and knowledge that participant is expected to master.
      a. For each scene of the module define the Trade and Level of target participant. Some
         cross-over is expected.
      b. Example Trades are: Controls, Electrical, Mechanical.
      c. Example Levels: Operation, Maintenance, Trouble-shooting.
   2. Emergency Operations shall include the following, as applicable:
      a. Instructions on meaning of warnings, trouble indications, and error messages.
      b. Instructions on stopping.
      c. Shutdown instructions for each type of emergency.
      d. Operating instructions for conditions outside of normal operating limits.
      e. Sequences for electric or electronic systems.
      f. Special operating instructions and procedures.
   3. Normal Operations shall include the following, as applicable:
      a. Startup procedures.
      b. Equipment or system break-in procedures.
c. Routine and normal operating instructions.
d. Regulation and control procedures.
e. Control sequences.
f. Safety procedures.
g. Instructions on stopping.
h. Normal shutdown instructions.
i. Operating procedures for system, subsystem, or equipment failure.
j. Seasonal and weekend operating instructions.
k. Required sequences for electric or electronic systems.
l. Special operating instructions and procedures.

4. Adjustments shall include the following:
a. Alignments.
b. Checking adjustments.
c. Noise and vibration adjustments.
d. Economy and efficiency adjustments.

5. Troubleshooting: Include the following:
a. Diagnostic instructions.
b. Test and inspection procedures.

6. Maintenance shall include the following:
a. Inspection procedures.
b. Types of cleaning agents to be used and methods of cleaning.
c. List of cleaning agents and methods of cleaning detrimental to product.
d. Procedures for routine cleaning.
e. Procedures for preventive maintenance.
f. Procedures for routine maintenance.
g. Instruction on use of special tools.

7. Repairs shall include the following:
a. Diagnosis instructions.
b. Repair instructions.
c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
d. Instructions for identifying parts and components.
e. Review of spare parts needed for operation and maintenance.

PART 2 PRODUCTS

2.1 RECORD DRAWINGS

A. Record Prints:
1. Maintain one set of blue or black-line white prints of the Construction Drawings and Shop Drawings.
2. Preparation: Mark Record Prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.
   a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
   b. Accurately record information in an understandable drawing technique.
   c. Obtain and record data for modifications as soon as specific item of work is accomplished. Record and check the markup before enclosing concealed installations.
3. Content: Types of items requiring marking include, but are not limited to, the following:
   a. Dimensional changes to Drawings.
   b. Revisions to details shown on Drawings.
c. Depths of foundations below first floor.
d. Locations and depths of underground utilities.
e. Revisions to routing of piping and conduits.
f. Revisions to electrical circuitry.
g. Actual equipment locations.
h. Duct size and routing.
i. Locations of concealed internal utilities.
j. Changes made by Change Order or Construction Change Directive.
k. Changes made following Owner’s written orders.
l. Details not on the original Agreement Drawings.
m. Field records for variable and concealed conditions.
n. Record information on the Work that is shown only schematically.

4. Mark the Construction Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. If Shop Drawings are marked, show cross-reference on the Construction Drawings.

5. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.

6. Mark important additional information that was either shown schematically or omitted from original Construction Drawings.

7. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Record CAD Drawings:
1. Immediately before inspection for Certificate of Completion, review marked-up Record Prints with Construction Manager. When authorized, prepare a full set of corrected CAD Drawings of the Construction Drawings to reflect Record/As-built conditions.

2. Format: Same CAD program, version, and operating system as the original Construction Drawings. One set of Record (As-Built) CAD files must be locked for record purposes. The other set of Record (As-Built) CAD files must be unlocked and completely manipulable for later use by the Owner for other project purposes.

3. Incorporate changes and additional information previously marked on Record Prints and Shop Drawings as applicable. Delete, redraw, and add details and notations where applicable. Scanned, TIFF, PDF or other non-manipulatable files are not acceptable as electronic copies.

C. Newly Prepared Record Drawings:
1. Prepare new drawings instead of preparing Record Drawings where the Owner’s Representative determines that neither the original Construction Drawings nor Shop Drawings are suitable to show actual installation.

2. New Drawings may be required when a Change Order is issued as a result of accepting an alternate, substitution, or other modification.

3. Integrate newly prepared Record Drawings into Record Drawing sets; comply with procedures for formatting, organizing, copying, binding, and submitting.

D. Format:
1. Identify and date each Record Drawing.

2. Record Prints: Organize Record Prints and newly prepared Record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.

3. Record CAD Drawings: Organize CAD information into separate electronic files that correspond to each sheet of the approved 100% Construction Drawings set, with Record Drawing mark-ups/additions. Name each file with the sheet identification. Include identification in each CAD file.

4. Identification as follows:
a. Project name.
b. Date.
c. Designation “DESIGN-BUILD RECORD DRAWINGS.”

2.2 RECORD SPECIFICATIONS

A. Preparation:
   1. Mark copy with the proprietary name and model number of products, materials, and equipment furnished. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.
   2. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
   3. Note related Record Product Data and Record Drawings where applicable.

2.3 RECORD PRODUCT DATA

A. Preparation:
   1. Mark Product Data to indicate the actual product installation where installation varies substantially from that required in Product Data submittal.
   2. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
   3. Include significant changes in the product delivered to site and changes in manufacturer's written instructions for installation.
   4. Note related Change Orders, Record Specifications, and Record Drawings where applicable.

2.4 MISCELLANEOUS RECORD SUBMITTALS

A. General:
   1. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

PART 3 EXECUTION

3.1 VERIFICATION OF CONDITIONS

A. Prior to installing any portion of the Work, Design-Builder must inspect the work already in place to receive the work to be installed and arrange for correction of defects in the existing workmanship, material or conditions that may adversely affect work to be installed. Such inspections must include test applications of the materials to be installed as required to establish the correct condition of surfaces involved. Where the specifications require a material to be installed under the supervision or inspection of the material manufacturer or its representative, Design-Builder must ensure that the manufacturer or its representative also inspects the work in place and issues a letter of approval to the Owner's Representative.

3.2 RECORDING AND MAINTENANCE

A. Recording:
   1. Maintain one copy of each submittal during the construction period for Design-Build Record Document purposes. Post changes and modifications to Design-Build Record Documents as they occur; do not wait until the end of project.
B. Maintenance of Record Documents and Samples:
   1. Store Record Documents and Samples in the field office apart from the Construction Documents used for construction. Do not use Design-Build Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Design-Build Record Documents for Owner’s reference during normal working hours.

3.3 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

A. Organization:
   1. Include a Section in the directory for each of the following:
      a. Master table of contents for directory.
      b. List of contacts.
      c. List of systems.
      d. List of equipment.
      e. Tables of contents.

B. List of Contacts
   1. List systems/equipment contacts; list by system, alphabetically.

C. List of Systems and Subsystems:
   1. List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.

D. List of Equipment:
   1. List equipment for each system, organized alphabetically by system. For pieces of equipment not part of a system, list alphabetically in separate list.

E. Tables of Contents:
   1. Include every table of contents for each emergency, operation and maintenance manual.

F. Identification:
   1. In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Construction Documents. If no designation exists, assign a designation according to American Society of Heating Refrigerating & Air Conditioning Engineers (ASHRAE) Guideline 4, “Preparation of Operating and Maintenance Documentation for Building Systems.”

G. All documents to be word searchable, scanned images of text will not be acceptable.

3.4 MANUALS-GENERAL

A. Organization:
   1. Unless otherwise required, 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.
   2. Each manual must contain the following materials, in the order listed:
      a. Title page.
      b. Table of contents.
B. Title Page:
   1. Enclose title page in transparent plastic sleeve. Include the following information:
      a. Subject matter included in manual.
      b. Name and address.
      c. Date of submittal.
      d. Name, address, and telephone number of Design-Builder.
      e. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents:
   1. 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.
   2. If operation or maintenance documentation requires more than one volume to
      accommodate data, include comprehensive table of contents for all volumes in each
      volume of the set.

D. Manual Contents:
   1. 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.
   2. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf D-ring binders, in thickness
      necessary to accommodate contents, sized to hold 8-1/2” by 11” paper; with clear plastic
      sleeve on spine to hold label describing contents and with pockets inside covers to hold
      folded oversize sheets.
      a. If two or more binders are necessary to accommodate data of a system, organize
         data in each binder into groupings by subsystem and related components. Cross-
         reference other binders if necessary to provide essential information for proper
         operation or maintenance of equipment or system.
      b. 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 (and volume count) for multiple-volume sets.
   3. 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.
   4. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic
      software diskettes for computerized electronic equipment.
   5. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.
   6. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
      a. If oversize drawings are necessary, fold drawings to same size as text pages and use
         as foldouts.
      b. 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.

3.5 EMERGENCY MANUALS

A. Content:
   1. Organize manual into a separate section for each of the following:
      a. Type of emergency.
      b. Emergency instructions.
      c. Emergency procedures.
B. Type of Emergency:
   1. Where applicable for each type of emergency required below, include instructions and
      procedures for each system, subsystem, piece of equipment, and component:
      a. Fire.
      b. Flood.
      c. Gas leak.
      d. Water leak.
      e. Power failure.
      f. Water outage.
      g. System, subsystem, or equipment failure.
      h. Chemical release or spill.

C. Emergency Instructions:
   1. Describe and explain warnings, trouble indications, error messages, and similar codes
      and signals. Include responsibilities of the Owner for notification of Installer, supplier, and
      manufacturer to maintain warranties.

D. Emergency Procedures:
   1. Include the following, as applicable:
      a. Instructions on stopping.
      b. Shutdown instructions for each type of emergency.
      c. Operating instructions for conditions outside normal operating limits.
      d. Required sequences for electric or electronic systems.
      e. Special operating instructions and procedures.

3.6 OPERATION MANUALS

A. Content:
   1. In addition to requirements in this Section, include operation data required in individual
      Specification Sections and the following information:
      a. Contacts.
         1) List names,
         2) Addresses,
         3) Phone numbers (direct contact, where possible)
         4) Email addresses.
      b. System, subsystem, and equipment descriptions.
      c. Performance and design requirement if Design-Builder is delegated design
         responsibility.
      d. Operating standards.
      e. Operating procedures.
      f. Operating logs.
      g. Wiring diagrams.
      h. Control diagrams.
      i. Piped system diagrams.
      j. Precautions against improper use.
      k. License requirements including inspection and renewal dates.

B. Descriptions:
   1. 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.

C. Operating Procedures:
   1. Include the following, as applicable:
      a. Startup procedures.
      b. Equipment or system break-in procedures.
      c. Routine and normal operating instructions.
      d. Regulation and control procedures.
      e. Instructions on stopping.
      f. Normal shutdown instructions.
      g. Seasonal and weekend operating instructions.
      h. Required sequences for electric or electronic systems.
      i. Special operating instructions and procedures.

D. Systems and Equipment Controls:
   1. Describe the sequence of operation, and diagram controls as installed.

E. Piped Systems:
   1. Diagram piping as installed, and identify color-coding where required for identification.

3.7 PRODUCT MAINTENANCE MANUAL

A. Content:
   1. 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.

B. Source Information:
   1. 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.

C. Product Information:
   1. 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.

D. Maintenance Procedures:
   1. Include manufacturer's written recommendations and the following:
      a. Inspection procedures.
      b. Types of cleaning agents to be used and methods of cleaning.
      c. List of cleaning agents and methods of cleaning detrimental to product.
      d. Schedule for routine cleaning and maintenance.
      e. Repair instructions.

E. Repair Materials and Sources:
   1. Include lists of materials and local sources of materials and related services.
F. Warranties and Bonds:
   1. Include copies of warranties and bonds and lists of circumstances and conditions that
      would affect validity of warranties or bonds.
   2. Include procedures to follow and required notifications for warranty claims.

3.8 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

A. Content:
   1. For each system, subsystem, and piece of equipment not part of a system, include
      source information, manufacturers’ 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.

B. Source Information:
   1. 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.

C. Manufacturer’s Maintenance Documentation:
   1. Manufacturers’ maintenance documentation including the following information for each
      component part or piece of equipment:
      a. Standard printed maintenance instructions and bulletins.
      b. Drawings, diagrams, and instructions required for maintenance, including
         disassembly and component removal, replacement, and assembly.
      c. Identification and nomenclature of parts and components.
      d. List of items recommended to be stocked as spare parts.

D. Maintenance Procedures:
   1. Include the following information and items that detail essential maintenance procedures:
      a. Test and inspection instructions.
      b. Troubleshooting guide.
      c. Precautions against improper maintenance.
   2. Disassembly; component removal, repair, and replacement; and reassembly instructions.
   3. Aligning, adjusting, and checking instructions.
   4. Demonstration and training videotape, if available.

E. Maintenance and Service Schedules:
   1. 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.
   2. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly,
      quarterly, semiannual, and annual frequencies.
   3. Maintenance and Service Record: Include manufacturers’ forms for recording
      maintenance.

F. Spare Parts List and Source Information:
   1. 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.

G. Maintenance Service Contracts:
   1. Include copies of maintenance agreements with name and telephone number of service
      agent.
H. Warranties and Bonds:
   1. Include copies of warranties and bonds and lists of circumstances and conditions that
      would affect validity of warranties or bonds.
   2. Include procedures to follow and required notifications for warranty claims.

3.9 SUBMITTAL REQUIREMENTS

A. The Project Proposal is not transferable to another Project Proposer. The Project Proposal
   must be submitted in the same name style and manner as is used on Contractor's license (or
   Joint Venture license as applicable). If a Project Proposal is submitted by an individual, name
   and postal address must be shown; if made by a firm or partnership, the name and postal
   address of the firm or partnership, and the signature of one or both partners must be shown; if
   made by a corporation, Project Proposal must show name of Owner's Representative under
   the laws of which the corporation was chartered, name of the corporation and title of the
   person who signs on behalf of the corporation. Corporate seal must be used.

B. Enhancements: The Performance Criteria identified in the Request for Proposal are minimum
   functional and operational requirements. To demonstrate the best value for the Owner
   encourages Proposers to submit enhancements to the RFP. All enhancements must be
   uniquely identified in the Project Proposals with detailed explanations of their benefits to the
   Owner, including, but not limited to a narrative, affected RFP section references, new
   performance criteria, new concept drawings, quality descriptions, and/or life cycle cost/benefit
   analysis as applicable. Schedule enhancements must be accompanied by detailed schedule
   information complying with the schedule submittal requirements dictated by the RFP. The
   Owner retains the right to refuse any and all enhancements and upgrades proposed.

3.10 PRODUCT CERTIFICATIONS

A. Where specifically indicated by pertinent Specification Sections, submit proper certification by
   recognized producer or association. Certifications must attest to product's compliance with
   requirements of the Contract Documents.

3.11 SHOP DRAWINGS

A. Submittals must be made in electronic and hard copy form and include one reproducible
   transparency of each original and 3 prints of each transparency, name and location of Project,
   name of Design-Builder, work order and Agreement numbers and cross references to
   Agreement documents. Number shop drawings consecutively. Make drawings legible and
   complete in every respect. Electronic drawing submittals must be in consistent AutoCAD or
   Revit format.

B. If Shop Drawings show variations from Agreement requirements because of standard shop
   practice or other reason, make specific mention of such variations in letter of transmittal, as
   well as on drawings, in order that (if acceptable) suitable action may be taken for proper
   adjustment of the Design-Build Agreement. Unless specific changes have been noted and
   accepted, no deviations from the Contract Documents will be permitted.

C. Transparencies will be returned to Design-Builder for Design-Builder's reproduction and use.

3.12 PRODUCT DATA/MATERIAL LISTS

A. Manufacturer's Standard Schematic Drawings:
   1. Modify drawings to delete information which is not applicable to Project.
   2. Supplement standard information to provide additional information applicable to Project.
B. Manufacturer's catalog sheets, brochures, diagrams, schedules, performance charts, illustrations and other standard descriptive data:
   1. Clearly mark each copy to identify pertinent materials, products or models.
   2. Show dimensions and clearances required.
   3. Show performance characteristics and capacities.
   4. Show wiring diagrams and controls.
   5. Include calculations when applicable.

C. Material Safety Data Sheets (MSDS): Include for materials which require manufacturer’s warnings and application instructions listed on MSDS provided by the product manufacturer.

3.13 SAMPLES

A. Physical examples to illustrate materials, equipment or workmanship, and to establish standards by which completed work is judged.

B. Where size of samples is not specified, office samples should be of sufficient size and quantity to clearly illustrate:
   1. Functional characteristics of product or material, with integrally related parts and attachment devices.
   2. After review, samples may be used in construction of Project.

C. Field Samples and Mockups:
   1. Erect at Project site at location acceptable to Owner’s Representative, unless otherwise approved.
   2. Construct each sample or mockup complete, including work of all trades required in finished work.
   3. Within twenty (20) days after NTP, Design-Build is required to provide Owner’s Representative with a comprehensive list of all Mock-ups to be completed at the Project. Owner’s Representative will review and approve this list.

3.14 SUBSTITUTIONS

A. Written acceptance from the Owner’s Representative is required for implementation or utilization of any substitution.
   1. The Design-Build Agreement is based on materials, equipment and methods described in Criteria Documents.
   2. Owner’s Representative will consider proposals for alternative materials, equipment and methods only when such proposals are accompanied by full and complete technical data and all other information required by Owner’s Representative to evaluate proposed substitution.
   3. Do not use alternative materials, equipment or methods unless such substitution has been specifically accepted for this work by Owner’s Representative.

B. Coordination: Acceptance of substitution will not relieve Design-Build from responsibility for compliance with all requirements of the Design Requirements and Performance Specifications, and Design-Build will be responsible, at Design-Build’s own expense, for changes in other parts of Design-Build’s work or work of others which may be caused by acceptance of substitution.

C. Proposed substitutions must be submitted no more than 30 days after Notice to Proceed. All substitutions will be considered Action Submittals.
D. Submit separate request for each product and support each request with:
   1. Product identification.
   2. Manufacturer’s representative name, address and contact information.
   3. Manufacturer’s literature.
   4. Samples, as applicable.
   5. Detailed comparison of proposed product with specified product.
   6. Name, address, and scope of correctional facilities projects on which product has been used, and date of installation.
   7. Data relating to changes in construction schedule, if any.
   8. Data regarding difference in cost, if any, between specified item and proposed substitute item.
   9. Historical reliability and maintenance data.
   10. Life-cycle value compared to specified product.
   11. Warranty comparison to specified product.

E. Substitute products will not be ordered without written acceptance of Owner’s Representative.

F. Owner’s Representative will determine acceptability of proposed substitutions (alternatives) and reserves the right to reject proposals due to insufficient information.

3.15 TECHNICAL PROPOSAL

A. Critical Success Factors (CSF) are those issues that the Owner considers essential to the success of this Project, and are the core essence of the Proposer’s responsibility. It is essential that the Proposer be responsive to the Owner in both the development of the response to the RFP and in the design and construction of the requirements of this Design-Build Project.
   1. Meet and/or exceed the minimum requirements of applicable Codes.
   2. Utilize the full capabilities of BIM to maximize the efficiency of the design process.
   3. Be consistent with the requirements of the Americans with Disabilities Act (ADA).
   4. Create a Project that is energy and water efficient.
   5. Thoroughly commission new systems to ensure efficient and reliable operation.
   6. Systematically furnish all required warranties, operation and maintenance manuals, and record documents and successfully transition and train facility staff, closing out the Project with no defects.

B. Proposed Design: Prepare written documents listed below to depict the Proposer’s design in response to the Owner’s requirements. The submittal requirements listed below are minimum requirements. Proposer may submit additional materials in the Project Proposal. Additional materials submitted by the Proposer may or may not be reviewed by the Owner at the Owner’s sole discretion. Internet links to websites are not permitted. Design narrative may include diagrams, graphic illustrations, conceptual sketches and ideas, exhibits, and photographic images. Drawings format shall be 24” x 36” or 30” x 42”. Floors plans, details, site plans, conceptual floor plans, etc. shall be no smaller than 1/8”=1’0” and no larger than 1/2”=1’0”.
   1. Provide individual technical approach plans, including backup documentation as appropriate, to identify the proposed types and operations of systems illustrating the best value for the Owner. Technical approach plans are to include:
      a. Narrative(s) detailing the basic approach(es).
      b. Conceptual layout(s) of building systems.
      c. Proposed systems including a description of types, efficiencies, quantities and capacities.
      d. Submit a Life Cycle Cost (LCC) analysis of proposed systems describing the Proposer’s approach for evaluating alternatives and developing cost effective designs, systems and components as part of sustainable design. Life-cycle benefit
analyses must be shown as present value amounts using a 5.5% discount rate, 20-year life cycle period, 3% energy costs escalation rate, 3% personnel/staff escalation rate and 2% maintenance cost escalation rate.

e. Approach to maintaining and servicing proposed systems.
f. Narrative(s) outlining the proven track record(s) of the proposed systems and vendors including tried and tested processes, systems and capabilities.

3.16 OPERATION AND MAINTENANCE MANUAL PREPARATION

A. Operation and Maintenance Documentation Directory:
1. Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.

B. Emergency Manual:
1. Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by the Owner staff for types of emergencies required.

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

D. Operation and Maintenance Manuals:
1. 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.
2. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
3. Prepare a separate manual for each system and subsystem, in the form of an instructional manual.
4. Prepare a recommended general overall preventative maintenance manual and include a schedule.

E. Manufacturers’ Data:
1. Where manuals contain manufacturers’ 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 include more than one item in a tabular format, identify each item using appropriate references from the Construction Documents. Identify data applicable to the Work and delete references to information not applicable.
2. Prepare supplementary text if manufacturers’ standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.

F. Drawings:
1. Prepare drawings supplementing manufacturer’s 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.
2. Do not use original Construction Documents as part of operation and maintenance manuals.
3. Comply with requirements of newly prepared Record/As-Built Drawings.
3.17 DEMONSTRATION AND TRAINING PREPARATION

A. General:
   1. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a combined training manual.
   2. Set up instructional equipment at instruction location.
   3. Script training module video clips to focus on defined staff Trade and Level.

3.18 TRAINING INSTRUCTION

A. Facilitator:
   1. Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Design-Builder and the Owner for number of participants, instruction times, and location.

B. Instructors:
   1. Engage qualified instructors to instruct the Owner’s staff to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

C. Scheduling:
   1. Provide instruction at mutually agreed upon times. For equipment that requires seasonal operation, provide similar instruction at start of each season.
   2. Design-Builder must coordinate with the Owner to create as comprehensive an overall training schedule as possible to facilitate the limited numbers of Owner staff that must be trained in all aspects of the new building. Schedule training with the Owner with at least twenty-one (21) calendar days advance notice.

D. Evaluation:
   1. At conclusion of each training module, assess and document each participant's mastery of module by use of an oral, written, or demonstration performance-based test, as applicable.

E. Cleanup:
   1. Collect used and leftover educational materials and give to Owner. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

F. Post Video Editing:
   1. Instructor to edit transcript so as to identify video clips that are targeted for different Operation and Maintenance (O&M) sections.

3.19 DEMONSTRATION AND TRAINING VIDEO INTERACTIVE DVD’S

A. General:
   1. Engage a qualified videographer to record all demonstration and training video DVDs. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.
   2. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. DVD Format:
   1. Provide high-quality color DVDs with hard plastic snap-case for each.
   2. All videos are to be shot by the same videographer.
C. Cameras:
1. Provide cameras with a minimum resolution of 1080i High-definition at 30 frames per second.
2. Cameras to be mounted on fluid head tripods.

D. Camera Setup:
1. Two identical cameras are to be used.
2. Camera one is a medium to wide shot which includes the trainer and display materials, white board, charts, etc. Camera does minimal panning and zooming. Camera one is the default camera: All footage from camera one to be continuously usable. A lavaliere (lapel) microphone, should be connected to Camera one.
3. Camera two is a close-up camera capturing details of whiteboards, machinery and, controls, etc. Camera two is outfitted with a medium-length shotgun microphone for clean back-up sound on audio channel 1. Audio channel 2 on Camera two is outfitted with second microphone at director’s station for scene descriptions and notes.
4. Both cameras shoot continuously to ease synchronization in editing.
5. Supplemental lighting may be required depending on room size/on-site or details being filmed.

E. Video Format:
1. Window Dubs: Provide minimum standard definition (SD) resolution, full color, on DVD, or suitable 2006 format.
2. Original Footage: High definition (HD) Digital video (DV) at full camera resolution.

F. Recording:
1. Mount camera one on tripod before starting recording. Display continuous running time.
2. Mount camera two on tripod before starting recording, unless otherwise necessary to show area of demonstration and training. Display continuous running time.
3. Shoot a slate at start of each session including Module, Trainer, Location, Date and Time.

G. Narration:
1. Describe scenes on video DVD by audio narration by microphone while video DVD is recorded, or by dubbing the sound after recording, whichever gives better results and clarity. Include description of items being viewed. Describe vantage point, indicating location, direction (by compass point), and elevation or story of construction.

H. Transcript:
1. Provide a typewritten transcript of the narration. Display images and running time captured from video DVD opposite the corresponding narration segment.
2. Transcripts to be generated from window dubs (raw video footage).
3. Raw transcript to be delivered to the trainer for marking of the video, tagging with the trade and level information and any content edits, for each video clip.
4. Trainer content edits to be incorporated into final transcript.

I. Video Editing Products & Organization:
1. Required Products:
   a. Clips edited and compressed for use with local-network training stations.
   b. Clips edited and compiled into DVDs & HD DVDs for alternate training methods. (Classroom, offsite, etc.)
   c. Edit video into clips per trainers edits of transcript. Name clips so as to facilitate compilation by trade and level. (Example: M16T05L03)
   d. A five second title card to appear at front of each clip identifying: Trade, Level, O&M section, instructor, facility, and date of recording.
2. Compile video clips by sequence, trade and level into the following movies. Provide menu for access by the following selections on DVDs & HD DVDs:
   a. Entire module in sequence.
   b. By Trade: Where more than one trade is identified in the module assemble the clips in sequence for that trade.
   c. By Level: Where more than one level is identified in the module, assemble the clips in sequence for that level.
   d. By O&M documentation section.

3.20 ELECTRONIC DOCUMENTATION LINKING

A. Hyperlink each training module video clip to the corresponding section of the narration and corresponding O&M document section.

3.21 SPECIAL TRAINING REQUIREMENTS FOR MECHANICAL EQUIPMENT

A. Training Responsibilities:
   1. Require that the mechanical subcontractor be responsible for mechanical training coordination, scheduling and ultimately to ensure that training is completed.
      a. Provide designated Owner personnel with a comprehensive training plan for mechanical equipment two months before the planned training.
      b. Provide the Owner with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of mechanical equipment including, but not limited to, chillers, boilers, pumps, air handling units, fans, terminal units and controls systems, etc.
   2. Start training with classroom sessions followed by hands-on training on each piece of equipment, which must illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
   3. If during demonstration the system fails to perform in accordance with the requirements of the O&M manual or sequence of operations, repair or adjust the system as necessary and repeat the demonstration.
   4. Engage the appropriate trade or manufacturer’s representative to provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing Design-Builder or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
   5. The controls subcontractor must attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
   6. The training sessions must follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
   7. Training must include:
      a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals. This material must be submitted and approved prior to being used in training.
      b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training must include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
      c. Discussion of relevant health and safety issues and concerns.
      d. Discussion of warranties and guarantees.
      e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. The format and training agenda in “The Commissioning Process,” ASHRAE Guideline 2005 is recommended.
i. Classroom sessions must include the use of overhead projections, slides, video/audio DVD material as might be appropriate.
j. Hands-on training must include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
k. The mechanical Design-Builder must fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
l. Training must occur after functional testing is complete, unless approved otherwise by the Owner.
m. Require the mechanical Design-Builder to provide training on each piece of equipment according to the requirements identified in the Performance Specifications.

END OF SECTION
PART 1  GENERAL

1.1  APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and shall include all Fire Protection Sections specified herein.

1.2  SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
1. Compliance with all codes and standards applicable to this jurisdiction.
2. Shop Drawings for Equipment
3. Coordination Documents
4. Record Drawings
5. Start-up Service and Building Commissioning
6. Instruction, Maintenance, and O & M Manuals
7. Work associated with Delivery, Storage, and Handling of products
8. Work associated with provision of Temporary Facilities
9. Preparation of Posted Operating Instructions
10. Meeting Project Safety and Indemnity requirements
11. Proper Cleaning and Closing
12. Supplying proper Warranty information
13. Supply specified Guarantee documentation
14. Design and provision of Supports and Anchors
15. Pipe Portals
16. Access Panels and Doors
17. Identification Markers
18. Coordination of Electrical requirements for equipment provided

1.3  DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide guidelines to the Contractor to provide all material and labor to design and install complete fire protection systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and he shall coordinate his work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the equipment, and risers and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and site systems, effort has been made to note existing utilities and services. However, the Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.
E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all plumbing system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The plumbing system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply plumbing devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

G. Heat tracing shall not be used in lieu of heated valve enclosures to protect the valves and supply piping from freezing. Where used to protect branch lines, the heat tracing system shall be specifically listed for use on branch lines. Electric supervision of the heat tracing system shall provide positive confirmation that the circuit is energized. Where any portion of a system is subject to freezing and temperatures cannot be reliably maintained at or above 40°F (4°C), the system shall be installed as a dry pipe or preaction system. Comply with NFPA-13.

1.4 DESCRIPTION OF BID DOCUMENTS

A. Specifications in general, describe quality and character of materials and equipment.

1.5 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

C. Below Grade: Buried in the ground or embedded in concrete slab on ground.

D. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.

E. Connect: Complete hook-up of item with required service.

F. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

G. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements.

H. Exposed: Not installed underground or concealed.

I. Furnish: To supply equipment and products as specified.
J. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

K. Install: To erect, mount and connect complete with related accessories.

L. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

M. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

N. NRTL: Nationally Recognized Testing Laboratory, including UL and/or ETL.

O. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

P. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

Q. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner.

R. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

S. Shall: An exhortation or command to complete the specified task.

T. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

U. Supply: To purchase, procure, acquire and deliver complete with related accessories.

V. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

W. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

X. Wiring: Raceway, fittings, wire, boxes and related items.

Y. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.6 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 21 Fire Suppression sections included herein.

B. Division 02: Existing Conditions.
   1. Coordination of excavation of trenches and the installation of piping on site.

C. Division 03: Concrete.
   1. All concrete work for Fire Suppression Division shall be included in Division 21 under the appropriate Sections and shall include:
      a. Concrete curbs and housekeeping pads for the equipment.
b. Thrust blocks for piping.

D. Division 07: Thermal and Moisture Protection.
   1. Sealants and caulking.
   2. Firestopping.

E. Division 09: Finishes:
   1. Division 21 installers shall perform all painting, except where specifically stated otherwise in Division 09.

F. Division 26: Electrical is related to work of:
   1. Fire protection alarms and relays.
   2. Detectors and monitoring.
   3. Power connections to all equipment.
   4. Life safety provisions.

1.7 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 21 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:
   1. NFPA Standards:
      b. NFPA 14: Standard for the Installation of Standpipe and Hose Systems (latest adopted version)
      c. NFPA 17: Standard for Dry Chemical Extinguishing Systems (latest adopted version)
      d. NFPA 17A: Standard for Wet Chemical Extinguishing Systems (latest adopted version)
      e. NFPA 20: Standard for the Installation of Stationary Pumps for Fire Protection (latest adopted version)
      g. NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances (latest adopted version)
      i. NFPA 70: National Electrical Code (latest adopted version)
      k. NFPA 80: Standard for Fire Doors and Other Opening Protective (latest adopted version)
m. NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems (latest adopted version)

2. Factory Mutual Global insurance company if declared by building Owner, including, but not limited to the following Data Sheets:
   b. Data Sheet 2-0: Installation Guidelines for Automatic Sprinklers
   c. Data Sheet 2-8: Earthquake Protection for Water-Based Fire Protection Systems
   d. Data Sheet 8-9: Storage of Class 1, 2, 3, 4 and Plastic Commodities
   e. Data Sheet 2-10R: Dry-Pipe, Deluge, Preaction Valves & Accessories
   f. Data Sheet 3-0: Hydraulics of Fire Protection Systems
   g. Data Sheet 4-4N: Standpipe and Hose Systems

3. Washington Building Codes enforced by the Authority Having Jurisdiction (AHJ):
   a. 2015 International Building Code (IBC) with State Amendments
   b. 2015 International Mechanical Code (IMC) with State Amendments
   c. 2015 Uniform Plumbing Code (UPC) with State Amendments
   d. 2015 International Fire Code (IFC) with State Amendment
   e. 2015 National Fuel Gas Code (NFGC) NFPA 54, WAC 51-52
   f. 2014 National Electrical Code (NEC)
   g. 2015 Washington State Energy Code, (WAC 51-11, WSEC)
   h. Washington State Ventilation and Indoor Air Quality Code, WA 51-13 (VIAQ)

4. Local, city, county and state codes and ordinances

5. Local and State Fire Prevention Districts.

6. Other applicable standards and references:
   a. UL and FM Compliance: Provide products, which are UL listed and FM approved.
   c. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
   e. Factory Mutual Approval Guide (Product listing, only).
   f. Factory Mutual Approval Guide and FM Pamphlet #20 "Rules for Installing Sprinklers" (Product listing and project review).
   g. Underwriters Laboratories, Inc.
   h. Industrial Risk Insurance Underwriters.
   i. Owner’s insurance agency.

F. Provide in accordance with appropriate referenced standards of the following:
   1. ADA - Americans with Disabilities Act.
   3. ASME - American Society of Mechanical Engineers.
   5. AWS - American Welding Society.
   8. ETL - Electrical Testing Laboratories.
   9. FM - Factory Mutual.
   10. IAPMO - International Association of Plumbing and Mechanical Officials.
   11. MSS - Manufacturer's Standardization Society.
   12. NEMA - National Electrical Manufacturer's Association.
   14. UL - Underwriter's Laboratories.

1.8 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality
levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner's Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Owner's Representative for a decision before proceeding.

1.9 QUALITY ASSURANCE

A. Manufacturer's Nameplates: Nameplates on manufactured items shall be aluminum or Type 304 stainless steel sheet, not less than 20 USG (0.0375")(riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data.

B. Current Models. All work shall be as follows:
1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 21, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.
1. All pipe, pipe fittings and valves shall be manufactured in North America. Alternatives may be acceptable, but must be submitted and approved by the Owner's Representative prior to bidding.
2. Upon request, the Owner's Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

E. Each product and/or equipment type shall be provided by one manufacturer. Mixtures of manufacturers for each product and/or equipment type are not acceptable. Example – all wet system sprinkler piping shall be supplied by one manufacturer while different piping systems may be provided by other manufacturers.

F. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner's Representative.
G. Welding Standards:
   1. Welding Qualifications:
      a. Certification: Each welder shall have a current AWS QC7 welding certification with
         successful completion of written test and welding samples in compliance with AWS
         D1.1. The Owner’s Representative reserves the right to request sample coupon test
         welds of each welder to validate quality of welding work.
   2. Welding Procedures:
      a. Steel Support Welding: All work shall be performed to meet or exceed the
         requirements of the American Welding Society AWS D1.1/D1.1M-Structural Welding
         Code-Steel.
      b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the
         American Welding Society AWS B2.1 Specification for Welding Procedure and
         Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX
         “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and
         Welding and Brazing Operators.”

1.10 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access.

E. Coordinate equipment and materials installation with other building components.

F. Verify all dimensions by field measurements.

G. Arrange for chases, slots, and openings in other building components to allow for installations.

H. 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.

I. Sequence, coordinate, and integrate installations of materials and equipment for efficient flow of the work.

J. Coordinate the cutting and patching of building components to accommodate the installation of equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

K. Install fire protection services and overhead equipment to provide the maximum headroom possible.

L. Install equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.
M. Coordinate the installation of materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, and other installations.

N. Coordinate connection of systems with exterior underground utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

O. Coordinate with Owner’s Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

P. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

Q. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.11 MINOR DEVIATIONS

A. The Contractor shall review the structural and architectural conditions and drawings affecting his work. It is the specific intention of this section that the contractor’s scope of work shall include
   1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

B. The Contractor shall study the operational requirements of each system, and shall arrange his work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor’s coordination of this section’s work with the “Electrical Work.” Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

C. Advice the Owner’s Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

1.12 PRODUCT SUBSTITUTIONS

A. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:
   1. The proposed substitution does not affect dimensions shown on drawings.
   2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
   3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
4. Maintenance and service parts available locally are readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to this proposed substitution.

1.13 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:
   1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner's Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
   2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
   3. Paper submittals will only be acceptable if specifically required by Division 01.
   4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.14 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.
   1. The shop drawings shall serve to record the coordination of the installation and location of all fire sprinkler heads, piping, HVAC equipment, ductwork, grilles, diffusers, lights, audio/video systems, electrical services and all system appurtenances.
   2. The Drawings shall include all mechanical rooms and floor plans.
   3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner's Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner's Representative.
   4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties
mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:
1. Two dimensional AutoCAD / Revit based documents:
   a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
   b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.
   c. Fire protection drawings shall indicate locations of all sprinkler heads and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Drawings shall incorporate all addenda items and change orders.
   f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.
2. Three dimensional Revit / BIM based documents (if required for project):
   a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Model shall incorporate all addenda items and change orders.
   f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner’s Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner’s Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.
1.15 REQUESTS FOR INFORMATION (RFIs).

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
   1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
   2. RFIs shall address single questions and related issues only.
   3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner’s Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
   2. Project number.
   3. Date.
   4. Name of Contractor.
   5. Name of Architect and Construction Manager.
   6. RFI number, numbered sequentially and unique.
   7. RFI subject.
   8. Specification section number and title and related paragraphs, as appropriate.
   9. Drawing number and detail references, as appropriate.
   10. Field dimensions and conditions, as appropriate.
   11. Contractor's suggested resolution. If Contractor’s suggested resolution impacts the contract time or the contract sum, Contractor shall state impact in the RFI.
   12. Contractor's signature.
   13. Attachments: Include sketches, descriptions, measurements, photos, product data, shop drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
      a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.
   1. The following Contractor-generated RFIs will be returned without action:
      a. Incomplete RFIs or inaccurately prepared RFIs.
      b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
      c. RFIs addressing multiple unrelated issues.
      d. Requests for approval of submittals.
      e. Requests for approval of substitutions.
      f. Requests for approval of Contractor's means and methods.
      g. Requests for information already indicated in the Contract Documents.
      h. Requests for adjustments in the Contract Time or the Contract Sum.
      i. Requests for interpretation of Engineer's actions on submittals.
   2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.
1.16 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked “Record Set” at the job site at all times and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including control devices, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance.

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all “Record Set” notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and electronic media (DVD disks) labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.17 START-UP SERVICE AND BUILDING COMMISSIONING

A. Prior to start-up, be assured that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of pumps, and other major pieces of equipment. Certify in writing compliance with this Paragraph, stating names of personnel involved and the date work was performed.

C. Refer to other Division 21 Sections for additional requirements.

1.18 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Upon completion of the work, the Contractor shall submit to the Owner’s Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section, bound in a durable binder. Refer to Division 01.

B. The Contractor shall be responsible for proper instruction of Owner’s personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 21 to be no less than 2 hours for each piece of equipment.

1.19 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.
B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

1.20 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.21 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.22 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner’s Representative.

1.23 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the
time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

2.2 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:

1. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.


B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.

1. Adjustable Steel Clevis Hangers: MSS Type 1.

2. Adjustable Steel Swivel Band Hangers: MSS Type 10.


4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
   a. Plate: Unguided type.
b. Plate: Guided type.
c. Plate: Hold-down clamp type.
5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Single Pipe Roller with Malleable Sockets: MSS Type 41.
9. Adjustable Roller Hangers: MSS Type 43.
10. Pipe Roll Stands: MSS Type 44.
11. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp or equal.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
   1. Steel Turnbuckles: MSS Type 13.
   2. Steel Clevises: MSS Type 14.
   3. Swivel Turnbuckles: MSS Type 15.
   5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated, provide factory-fabricated building attachments of one of the following types listed.
   1. Concrete Inserts: HCI-MD (for metal deck) or HCI-WF (for wood forms) cast-in anchors by Hilti Inc. or MSS Type 18 or Blue Banger Hanger by Simpson
   2. Steel Brackets: One of the following for indicated loading:
      b. Medium Duty: MSS Type 32.
      c. Heavy Duty: MSS Type 33.
   3. Horizontal Travelers: MSS Type 58.
   4. Concrete Screw Anchors: Hilti Kwik HUS EZ or equal.
   5. Torque-Controlled Expansion Anchor: Hilti Kwik Bolt TZ or equal.

G. Miscellaneous Materials:
   1. Metal Framing: Provide products complying with NEMA STD ML1.
   2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
   3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
   4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.
   5. Pipe Brackets: "HoldRite" copper plated brackets. Insulate brackets attached to metal studs with felt.
2.3 SEISMIC RESTRAINT AND VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 210548 Vibration Isolation for Fire Protection Equipment or Section 210549 Seismic Restraint for Fire Protection Piping and Equipment, as applicable.

2.4 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20-gauge steel, 1" flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each concealed valve. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner’s Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, or equal.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

2.5 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 21 Sections. Where more than a single type is specified for application, selection is at installer’s option, but provide single selection for each product category. Stencils are not acceptable.

B. Plastic Pipe Markers:
   2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape.
   3. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

C. Underground-Type Plastic Line Markers: Provide 6" wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.
D. Valve Tags:
   1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with
      stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve
      numbers 1/2" high, and with 5/32" hole for fastener. Fill tag engraving with black enamel.
   2. Plastic Laminate Valve Tags: Provide 3/32" thick engraved plastic laminate valve tags,
      with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2"
      high, and with 5/32" hole for fasteners.
   3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass
      S-hooks of the sizes required for proper attachment of tags to valves, and manufactured
      specifically for that purpose.
   4. Access Panel Markers: Provide 1/16" thick engraved plastic laminate access panel
      markers, with abbreviations and numbers corresponding to concealed valve. Include 1/8"
      center hole to allow attachment.

E. Plastic Equipment Signs:
   1. Provide 4-1/2" x 6" (minimum) plastic laminate sign, ANSI A.13 color coded with
      engraved white core lettering.
   2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive
      where screws cannot or should not penetrate the substrate.
   3. Nomenclature: Include the following, matching terminology on schedules as closely as
      possible:
      a. Name and plan number.
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters, such as pressure, rpm, etc.

F. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., Brimar or equal.

2.6 ELECTRICAL

A. General:
   1. All electrical material, equipment, and apparatus specified herein shall conform to the
      requirements of Division 26.

B. Quality Assurance:
   1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for
      location and use - no exceptions.

C. Low Voltage Control Wiring:
   1. General: 14-gauge, Type THHN, color coded, installed in conduit.
   2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp.,
      Senator Wire and Cable Co., Southwire Co, or equal.

PART 3 EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master fitter and shall result in an
   installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any
   diagonal, or otherwise irregular work, unless so indicated on Drawings or approved by
   Owner's Representative.
3.2 MANUFACTURER'S DIRECTIONS

A. Follow manufacturers’ directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.3 INSTALLATION

A. Coordinate the work between the various Fire Protection Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Owner’s Representative and at the Contractor’s cost. Coordinate wall and ceiling work with the General Contractor, and his subcontractors in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

3.4 SUPPORTS AND HANGERS

A. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms.

B. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

C. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

D. Install hangers within 12 inches of every change in piping direction (only one required on either side of elbow), end of a deadead pipe run or concentrated load, and within 36 inches of every major piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

E. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

F. Support sprinkler piping independently of other piping.

G. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.
H. Hanger sizing and support points shall be designed to support a minimum of five times the weight of the water-filled pipe plus 250 lbs. at each point of piping support as required by NFPA-13.

I. Hanger Spacing in accordance with following minimum schedules (other pipe/rod sizes and hanger spacings may be used in accordance with NFPA-13 or more restrictive local codes):
   1. Steel Pipe:
      | Pipe Size | Hanger Spacing (Maximum) | Rod Size (Minimum) |
      |-----------|--------------------------|-------------------|
      | Up to 1"  | 7 feet                   | 3/8"              |
      | 1-1/4" to 2" | 10 feet               | 3/8"              |
      | 2-1/2" to 3" | 12 feet               | 3/8"              |
      | 4" to 8"  | 15 feet                  | 1/2"              |
   2. Plastic Pipe:
      | Pipe Size | Hanger Spacing (Maximum) | Rod Size (Minimum) |
      |-----------|--------------------------|-------------------|
      | Up to 2"  | 4 feet                   | 3/8"              |
      | 2-1/2" to 8" | 6 feet                | 1/2"              |

J. Sloping, Air Venting, and Draining:
   1. Slope all piping as specified and as indicated, true to line and grade, and free of traps and air pockets. Wet piping is not required to be sloped, but must be installed flat or with slopes to allow maintenance flushing as required by NFPA-13. Unless indicated otherwise, slope piping in the direction of flow as follows:
      | Service            | Slope                  |
      |-------------------|------------------------|
      | Wet               | Not required           |
      | Dry/Preaction Mains | 1/4"/10’              |
      | Dry/Preaction Branches | 1/2”/10’             |

K. Provisions for Movement:
   1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
   2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.

L. Installation of Anchors:
   1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
   2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
   3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
   4. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

M. Adjusting:
   1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
   2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
   3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
3.5 PIPE PORTALS
A. Install per manufacturer’s instructions.
B. Coordinate with other trades they are installed when roofing is being installed.

3.6 VIBRATION CONTROL ISOLATORS
A. Comply with manufacturer’s recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.
B. Comply with manufacturer’s instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.
C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.
D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.
E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.
F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.7 ELECTRICAL COORDINATION
A. Division 21 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.
B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer’s written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA’s “Standard of Installation” to ensure that products fulfill requirements.
C. Division 21 has responsibilities for electrically powered fire protection equipment which is specified in Division 21 Specifications or scheduled on Division 21 Drawings as follows:
1. Motors: Furnish and install all motors necessary for mechanical equipment.
2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 21 equipment, also furnish and install the power wiring between starter and motor.
3. Variable Frequency Drives: Provide all VFD’s associated with fire protection equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
4. Disconnects: Provide the disconnects which are part of factory wired Division 21 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.

5. Controls: Division 21 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
   a. Control relays necessary for controlling Division 21 equipment.
   b. Control transformers necessary for providing power to controls for Division 21 equipment.
   c. Low or non-load voltage control components.
   d. Non-life safety related valve or damper actuators.
   e. Float switches.
   g. Communications wiring and conduit between control devices and fire protection equipment.
   h. Raceway to support control cabling.

D. Division 26 Electrical Responsibilities:
   1. Disconnects: Provide all disconnects necessary for Division 21 fire protection equipment which are not provided as part of factory wired Division 21 equipment. Provide power wiring to all disconnects. In addition, provide power wiring between motor and disconnect when the disconnect is not factory installed.
   2. Controls: Division 26 is responsible for providing power to control panels and provide final power connection to Division 21 provided control transformers.
   3. Fire Sprinkler System: Division 26 is responsible for providing power wiring to fire protection controls including flow switches and alarm bells.
   4. Specialized fire suppression systems: Division 26 is responsible for providing power wiring to suppression system and its controls.

3.8 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping System Identification:
   1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
   2. Locate pipe markers as follows:
      a. Near each valve and control device.
      b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
      c. Near locations where pipes pass through walls or floors/ceilings, or other non-accessible enclosures.
      d. At access doors, manholes, and similar access points which permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.
      f. Spaced horizontally at maximum spacing of 20' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.

C. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.
D. Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:
1. Main control and operating valves, including safety devices.
2. Meters, gauges and similar units.
3. Sprinkler and standpipe equipment.

E. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

3.9 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner’s Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 210500 - Basic Fire Protection Materials and Methods, and other Sections in Division 21 specified herein.

1.2 SUMMARY

A. This Section includes the following:
   1. Seismic restraint and support of piping and fire protection equipment as required by code and as designed by project registered professional Structural Engineer.
   2. Mechanical component supports and the means by which they are attached to the fire protection component shall be designed for the forces and displacements determined in ASCI 7-10 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the mechanical component.

1.3 DEFINITIONS

A. AHJ: Authority Having Jurisdiction

B. ASCE: American Society of Civil Engineers

C. Building Seismic Design Category: The directions of application of seismic forces used in the design shall be those which will produce the most critical load effects. Seismic Design Categories are classified as A, B, C, D, E or F. Refer to Architectural and Structural Designs for project specific classification.

D. Fire Protection Attachments: Means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

E. Fire Protection Components: Elements, including, but not limited to, pumps, pipes and risers.

F. Fire Protection Supports: Those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, snubbers, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.


H. ICC-ES: ICC-Evaluation Service

I. NFPA: National Fire Protection Association

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Section 210500: Basic Fire Protection Materials and Methods
B. Section 210548: Vibration Isolation for Fire Protection Piping and Equipment

1.5 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Provide systems that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Structural Performance: Restraint devices and systems shall withstand the effects of locally defined gravity loads, seismic loads, dead loads, live loads, winds loads and stresses within limits and under conditions indicated according to the Building Code and ASCE 7. Coordinate all support structures and restraint systems with project registered professional Structural Engineer.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

D. Codes and Standards: Provide components conforming to the seismic load requirements of the latest addition of the local building code and the following:
   1. International Building Code with State Amendments
   2. NFPA-13: Standard for the Installation of Sprinkler Systems
   4. Cooper B-Line/Tolco: Supports and Attachments of Non-Structural Fire Protection Systems
   5. Erico International: Seismic Sway Bracing for Fire Sprinkler Systems

1.6 APPLICABILITY

A. Provide seismic bracing at the following locations per NFPA-13:
   1. Transverse bracing shall be provided at 40 feet (12.2 m) maximum intervals on center except where a lesser spacing is indicated in the NFPA-13 tables.
   2. Longitudinal bracing shall be provided at 80 feet (24.4 m) maximum intervals on center except where a lesser spacing is indicated in the NFPA-13 tables. This includes feed and cross mains.
   3. Brace a change of direction longer than 12 feet (3.7m).

B. Seismically restrained systems shall not move more than 2” when pushed at any location and shall not impact other nonstructural components or building structure. Any free movement greater than 0.25” shall use a design force for restraint elements that are doubled (2 x Fp) per ASCE 7.

1.7 PERFORMANCE REQUIREMENTS

A. Component Importance Factor:
   1. Ip=1.5
1.8 SUBMITTALS

A. Product Data:
   1. Include rated load, rated deflection, and overload capacity for each device or system.
   2. 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 evaluation service or agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   3. Submit seismic brace product details detailing compliance with the specifications.
   4. Where products from pre-approved manufacturers cannot be used, special details must be submitted for approval.

B. Seismic Restraint Calculations
   1. Seismic restraint calculations must be provided for all connections to the structure.
   2. Calculations must be stamped by a registered professional Structural Engineer.

1.9 ENGINEERED PIPING SYSTEMS

A. Where the piping system design indicated on the plans utilizes pre-approved seismic restraint components and flexible connectors the following requirements apply:
   1. Pre-approved products must be installed as shown.
   2. If product substitutions or design changes are made the contractor must provide certified design of the piping system and meet the following conditions:
      a. Certification must be provided by a registered professional Structural Engineer.
      b. Certification shall include a statement that all systems have been checked for loads and stresses and that no excessive loads or stresses exist.
      c. Forces on all anchors, guides, supports, and restraints must not exceed those shown in the original design unless the structure is checked for the larger loads at no cost to the owner.

B. Where the piping system design is not indicated on the drawings the design is delegated to the contractor with the following requirements for piping certification and analysis:
   1. The supports, anchors, seismic braces for fire protection systems.
   2. The results of the analysis shall include reactions at restraints and anchors, maximum pipe displacements and a code compliant report indicating maximum pipe stresses.
   3. Where required, seismic restraint components, anchors, expansion compensators and flexible connectors shall be incorporated into the design of the systems.
   4. The analysis and design must be performed by a Structural Engineer with 5 years of experience in this field.

1.10 MANUFACTURER AND CONTRACTOR RESPONSIBILITIES

A. All seismic restraints shall be designed by a registered professional Structural Engineer.

B. Seismic restraint layouts for piping shall be added to the contractor’s shop drawings and shall include:
   1. The number, size and location of seismic braces.
   2. Maximum support loads and seismic loads at the seismic brace locations.

C. Installations not addressed by the states pre-approval process must be designed, detailed and submitted along with the shop drawings.
D. Submit seismic restraint layout drawings and special details for approval of the project registered professional Structural Engineer.

E. Seismic restraint layout drawings shall bear the stamp and signature of the registered professional Structural Engineer who designed the layout of the braces.

1.11 LOADS ON STRUCTURE

A. The responsibility of determining allowable loads on the structure is the sole responsibility of the project registered professional Structural Engineer.

B. Maximum support loads and seismic brace loads on the structure must be less than the maximum allowable loads defined by the project registered professional Structural Engineer, as shown on the plans.

C. Where maximum loads are not listed on the plans or the maximum allowable loads cannot be met, any additional support steel required to reduce support and seismic bracing loads on the structure shall be designed by the project registered professional Structural Engineer.

D. Mechanical component supports and the means by which that are attached to the component shall be designed for the forces and displacements determined in ASCE 7-10 Section 13.3.1 and 13.3.2. Such supports include structural members, braces, frames, skirts, legs, saddles, pedestals, cables, guys, stays, snubbers, and tethers, as well as elements forged or cast as a part of the fire protection component.

E. Mechanical supports are those members, assemblies of members, or manufactured elements, including braces, frames, legs, lugs, hangers, saddles, or struts, and associated fasteners that transmit loads between nonstructural components and their attachments to the structure.

F. Mechanical attachments are the means by which components or supports of nonstructural components are secured or connected to the seismic force-resisting system of the structure. Such attachments include anchor bolts, welded connections, and mechanical fasteners.

1.12 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.1 INTENT

A. All seismic restraints described in this section shall be the product of a single manufacturer.

B. Eaton B-Line/Tolco and Erico products are the basis of these specifications; products of other manufacturers may be submitted for review provided their systems strictly comply with the specifications.

2.2 SEISMIC SWAY BRACING

A. Seismic sway braces shall consist of galvanized steel aircraft cables, steel angles or steel struts.
B. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads. Brace end connections shall be steel assemblies that swivel to the final installation angle.

C. Cable brace assemblies shall have published strength and stiffness ratings based on testing per FM-1950 standards.

D. Angle or strut bracket assemblies shall be FM Approved except as noted below.

E. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps.

F. Cable brace bracket assemblies shall be Type SCB or SCBH. Solid brace bracket assemblies shall be Type SSB-FM, SSBS-FM or SHB-FM. All bracket assemblies shall have published strength and stiffness values based on testing per FM-1950.

G. Rod clamps shall be Type SRC or UCC.

PART 3 EXECUTION

3.1 GENERAL

A. Contractor’s Statement of Responsibility: Each contractor responsible for installing a Designated Seismic System or any seismic resisting component must submit a statement of responsibility prior to the commencement of work to include acknowledgment of awareness of the need for Special Inspections.

B. All seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

C. No connections between the piping and the building structure shall be made that degrades the seismic restraint system herein specified.

D. Any conflicts with other trades due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner’s Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor’s expense.

E. Installation of seismic restraints must not cause any change of position of equipment or piping resulting in stresses or misalignment.

F. Install seismic-restraint devices using methods approved by an evaluation service or agency acceptable to the authorities having jurisdiction, providing required submittals for component.

3.2 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, 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.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 210500 - Basic Fire Protection Materials and Methods, and other Sections in Division 21 specified herein.

1.2 DEFINITIONS

A. Pipe sizes used in this Section are nominal pipe size (NPS) specified in inches.

B. Working plans as used in this Section refer to documents (including drawings and calculations) prepared pursuant to requirements in NFPA-13 for obtaining approval of AHJ (Authority Having Jurisdiction).

C. NICET - National Institute for Certification in Engineering Technologies.

D. Other definitions for fire protection systems are included in referenced NFPA Standards.

E. FM – Factory Mutual Global insurance company.

1.3 DESCRIPTION OF WORK

A. The work includes designing, providing and installing a complete and fully operable automatic sprinkler system as described in this Section of the Specification and as shown on the contract construction drawings and shall be in accordance with rules, regulations and standards as required by the authorities having jurisdiction.
   1. State.
   2. City.
   3. Building Department.
   4. Fire Prevention Division, Fire Marshal’s Office.
   5. Factory Mutual Global insurance if declared by Owner.

B. Work includes but is not limited to the following:
   1. Automatic Wet Type Sprinkler System.
   2. Standpipes.
   3. Piping
   4. Sprinkler heads.
   5. Remodeling of existing systems.
   6. All cutting and patching.
   7. Provide all pipe, fittings, sprinklers, valves, signs, flow switches, tamper switches, protective painting, test connections, drains and tests necessary to make the entire system complete and operative.
   8. Coordinate with plumbing contractor for capacity of all sprinkler main, test, and auxiliary drain connections.
   9. Valve tags and instruction plates shall be mounted and/or hung per local fire department requirements.
   10. All required fire extinguishers.
   11. All sleeves and inserts.
   12. Drain riser, minimum 3” diameter, shall be provided adjacent to each standpipe riser for testing and draining.
13. Provide hose valve with cap downstream of sprinkler system pressure reducing valves for the purpose of testing. Hose valve shall be sized to provide full flow through pressure reducing valve.
14. All trenching and backfilling, including culverts under rails and guard posts where required.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Division 09: Finishes of exposed materials.
B. Section 210500: Basic Materials and Methods.
C. Section 210548: Vibration Isolation for Fire Protection Equipment.
D. Section 210549: Seismic Restraint for Fire Protection Piping and Equipment.
E. Division 22: Coordination with Plumbing design for location and sizes of indirect sanitary sewage drainage termination, floor sinks and/or hub drains. Fire protection designer shall provide required locations of drain locations prior to installation of plumbing work.
F. Division 26: Electrical. Coordinate for electrical wiring of detectors, flow alarm switches, tamper switches, connection to VESDA system, fire alarm bell, connection by life safety section for remote monitoring and starting of fire pump, and power to fire pumps. All electrical devices used for this system shall be compatible with the fire alarm system. Coordinate with electrical for electric fire pump motor size and emergency generator sizing.

1.5 DESIGN DESCRIPTION

A. This section of the specification combined with any of the contract drawings are intended as a guide to establish a basis of design for the systems required.
B. Contractor shall examine the existing conditions, the Architectural, Interior Design, Structural, Mechanical, Plumbing, and Electrical drawings, layout and install a complete hydraulically sized sprinkler system for all areas. Access and maintenance space shall be provided for all valves and equipment to be used.
   1. System shall start 5'-0" from perimeter wall and extend throughout the building. Fire main beyond 5'-0" perimeter is provided under Division 02 work. System shall start at connection to utility main, with double detector check backflow prevention assembly, and extend throughout the building.
   2. Contractor shall contact Owner’s insurance agency to incorporate insurer's design requirements in this layout document. Factory Mutual may review layout drawings and calculations. Incorporate all of their design criteria into documents.
C. Office Areas: The main building shall be served with a wet type sprinkler system. A main riser shall be located in the stairwells with sprinkler zone valves on each floor.
D. All areas shall be sprinklered as the construction progresses, including accessible pipe chases, elevator hoistways, etc. Provide shutoff valve with tamper switch for elevator hoistways. Provide shutoff valve with tamper switch for elevator machine room. Comply with NFPA 13 and Building Code.
E. Base Building construction shall include upright heads with tees with 1" outlets for future drop in areas with no ceiling. Areas with ceilings, including finished core areas, lobbies, corridors or as noted herein shall have concealed or recessed pendant heads installed as part of the base
building construction. Unfinished areas shall be provided with upright type heads. Heads will be relocated to the finished ceiling tile under the tenant improvement contract.

F. Install standpipe risers in each of the stairwells with fire department valves on each floor level. Provide allowance for 500 gpm at 100 psig at most remote fire department valves. Fire department valves not in stairwell shall be housed in cabinets. Provide roof manifold at top of each standpipe.

G. Pressure restricting devices shall be installed on any branch outlet exceeding 100 psi.

H. All electrical devices used for this system shall be compatible with the fire alarm system as referred in Division 26 work.

1.6 HYDRAULIC DESIGN

A. System shall be a straight line or gridded system per NFPA-13 with the following exceptions:
   1. For all systems the design area shall be the hydraulically most demanding rectangular area.
   2. Minimum pressure for any sprinkler head shall not be less than 7 psi.
   3. Velocity in fire pump suction piping shall not exceed 15 feet per second.

B. Fire Standpipes: Pipe schedule per IBC, Chapter 9 or hydraulically calculated at 500 GPM for first standpipe and 250 GPM for each additional standpipe.

C. Total Combined Inside & Outside Hose Allowances: Hydraulic calculations shall include an allowance for hose streams, added at the point of connection to the water supply.

D. Safety Factor: 10 psi, or 10 percent of static and residual pressure, whichever is greater.

E. Sprinkler system Occupancy Hazard Classifications shall be approved by authorities having jurisdiction:
   1. Air Distribution Plenums: Light Hazard (FM HC-1).
   2. Automobile Parking Areas: Ordinary Hazard, Group 1 (FM HC-2).
   3. Building Service Areas: Ordinary Hazard, Group 1 (FM HC-2).
   5. Corridors: Light Hazard (FM HC-1).
   6. Dry Cleaners: Ordinary Hazard, Group 2 (FM HC-2).
   7. Electrical Equipment Rooms: Ordinary Hazard, Group 1 (FM HC-2).
   8. Fire Riser Room: Ordinary Hazard, Group 1 (FM HC-2).
  12. Laundries: Ordinary Hazard, Group 1 (FM HC-2).
  15. Loading Docks with Tractor Trailers: Ordinary Hazard, Group 2 (FM HC-3).
  17. MDF/IDF/Electronic Data Hall: Ordinary Hazard, Group 1 (FM HC-2).
  18. Mechanical Equipment Rooms: Ordinary Hazard, Group 1 (FM HC-2).
  20. Pump Room: Ordinary Hazard, Group 1 (FM HC-2).
  22. Residential Living Areas: Light Hazard (FM HC-1).
  23. Restaurant Seating Areas: Light Hazard (FM HC-1).
24. Restaurant Service Areas: Ordinary Hazard, Group 1 (FM HC-2).

F. Minimum Density for Automatic-Sprinkler Piping Design shall comply with the following:
   1. Light Hazard Areas: Water density of 0.10 GPM per square foot calculated for an area of 1500 square feet in the most remote location.
   2. Ordinary Group I Hazard Areas: Water density of 0.15 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.
   3. Ordinary Group II Hazard Areas: Water density of 0.20 GPM per square foot calculated for an area of 1500 square feet in the most remote locations.
   4. Extra Group I Hazard Areas: Water density of 0.30 GPM per square foot calculated for an area of 2500 square feet in the most remote locations.
   5. Extra Group II Hazard Areas: Water density of 0.40 GPM per square foot calculated for an area of 2500 square feet in the most remote locations.

G. Head spacing shall not exceed the limits described in NFPA-13.
   2. Ordinary Hazard: 130 sq.ft.
   3. Extra Hazard: 100 sq.ft.

H. Maximum floor areas protected by any one sprinkler system riser:
   1. Light Hazard: 52,000 sq.ft.
   2. Ordinary Hazard: 52,000 sq.ft.
   3. Extra Hazard: 40,000 sq.ft.

I. Flow Data: Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.

J. Other spacing requirements:
   1. Maximum spacing between heads for Light Hazard and Ordinary Hazard shall not exceed 15 feet (4.6 m).
   2. Maximum spacing between heads for Extra Hazard shall not exceed 12 feet (3.7 m).
   3. The distance from sprinklers to walls shall not exceed 7.5 feet (2.3 m) for Light and Ordinary Hazard.
   4. Sprinkler heads shall not be located closer than 4 inches (100 mm) from a wall.
   5. Sprinklers shall not be spaced closer than 6 feet (1.8 m) on center.

1.7 QUALITY ASSURANCE

A. The Contractor for the fire protection installation shall be duly qualified Fire Protection Contractor, experienced and regularly engaged in the installation of fire protection systems with a license classification of C-16. Where local authorities require additional licensing of the Fire Protection Contractor, and/or workmen, such a license shall be mandatory for a prospective Contractor.
   1. Contractor is to verify flow data (static pressure, residual pressure and GPM flowing) available at site and provide design for available pressure and flow.
   2. The Fire Protection contractor shall be the Engineer of Record for the automatic sprinkler and standpipe system.
   3. Permits - The Fire Protection Contractor shall obtain permits for the installation or construction as required for approval and installation of the fire protection system. The Fire Protection Contractor shall submit working plans to the authorities having jurisdiction to obtain approval.
B. Welding Standards:
   1. Welding Qualifications:
      a. Certification: Each welder shall have a current AWS QC7 welding certification with
         successful completion of written test and welding samples in compliance with AWS
         D1.1. The Owner’s Representative reserves the right to request sample coupon test
         welds of each welder to validate quality of welding work.
   2. Welding Procedures:
      a. Steel Support Welding: All work shall be performed to meet or exceed the
         requirements of the American Welding Society AWS D1.1/D1.1M-Structural Welding
         Code-Steel.
      b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the
         American Welding Society AWS B2.1 Specification for Welding Procedure and
         Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX
         “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and
         Welding and Brazing Operators.”

1.8 SUBMITTALS

A. Product Data: Submit six copies of manufacturer’s technical data and installation instructions
   for fire protection materials and products.
   1. Thirty days after the awarding of contract, contractor shall submit list of manufacturer’s
      names and model numbers for review and comment to Owner’s Representative. This list
      shall identify any prior approved substituted items contractor wishes to use. Do not
      submit technical data until list has been approved.
   2. Prior to construction submit for review and comment items including but not be limited to
      the following:
      a. Coordinated layout drawings. Lettering shall be minimum 1/8” high.
      b. Sprinklers and escutcheons - designating area of use.
      c. Valves, valve boxes, flow switches, and tamper switches.
      d. Provide Fire Marshal approval numbers for flow switches and tamper switches.
      e. Pipe, fittings, sway bracing, inserts, anchors and hangers.
      f. Inspector’s test and drain station.
      g. Fire department connections.
      h. Hose valves, pressure relief valves, and pressure reducing valves.
      i. Fire pumps with performance curve.
   3. To assure uniformity and compatibility of piping components in grooved piping systems,
      all grooved products utilized shall be supplied by a single manufacturer. Grooving tools
      shall be of the same manufacturer as the grooved components.

B. Working Plans: Prepare scaled working plans for fire protection pipe and fittings including, but
   not necessarily limited to, pipe and tube sizes, locations, and elevations and slopes of
   horizontal runs, wall and floor penetrations, and connections. Indicate interface between and
   spatial relationship to piping and adjacent equipment. Lettering shall be minimum 1/8” high.
   1. Spacing of fire sprinklers shall be coordinated with lights, air conditioning outlets, sound
      speakers, architectural reflected ceiling plan; obstruction from light fixtures and other
      architectural features; and sprinkler piping shall be coordinated with HVAC ductwork &
      piping, plumbing, electrical conduit, cable trays and structure prior to the installation.
      Drawings shall be composite type including mechanical, plumbing and lighting equipment
      with sprinkler and sprinkler drain piping.

C. Submittal Drawings: Submit shop drawings to Agency having jurisdiction for approval bearing
   engineer of record stamp bearing preparer’s NICET stamp. Submit six approved copies,
bearing stamp and/or signature of Authority Having Jurisdiction to the Owner's Representative for review and comment.
1. Contractor shall submit sprinkler head locations to architect for approval.
2. Each calculation shall include legible schematic of system showing all hydraulic reference points.

D. Hydraulic Calculations: Prepare hydraulic calculations of fire protection systems. Submit to Authority Having Jurisdiction for approval. Submit six approved copies, bearing stamp, and/or signature of Agency having jurisdiction to Owner’s Representative for review and comment.
1. Contractor shall submit published piping friction loss data from manufacturer with hydraulic calculations.

E. Certificate of Installation: Submit certificate upon completion of fire protection piping work, which indicates that work has been tested in accordance with NFPA-13, and also that system is operational, complete, and has no defects.

F. Maintenance Data: Submit maintenance data and parts lists for fire protection materials and products. Include this data, product data, shop drawings, approval drawings, approval calculation, certificate of installation, and record drawings in maintenance manual; in accordance with requirements of the General Conditions and of Division 01.

G. Operating and Maintenance Instructions: Provide the Owner with three sets of operating and maintenance instructions covering completely the operation and maintenance of sprinkler equipment and controls. Manual shall be assembled in a 3-ring binder and arranged in following sections:
1. Site Utilities: Drawings showing location, size, depth of all connections, valve boxes, manholes, etc., as installed.
2. A chart tabulating all types of pipe fittings, valves, and piping specialties installed in each system.
3. A chart tabulating all pressures, valve settings for fire department and sprinkler pressure reducing valves. Provide pressure reducing valve flow test documentation.
4. Manufacturer's brochures of all sprinkler heads.
5. Manufacturer's brochures of fire pumps, jockey pump and controllers.
6. Tamper switches and flow switches.
7. Fire Department connections.
8. Reproducible copies of approved working drawings prepared to facilitate the actual installation of ductwork and piping. Drawings shall indicate location of all concealed valves, and other apparatus.
10. Approval Calculations.
13. The Contractor is responsible for proper instruction of Owner's personnel for operation and maintenance of all material, equipment and apparatus provided.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01. Handle components carefully to prevent damage, denting, and scoring. Do not install damaged components. Damaged components shall be replaced with new components.

B. Store/protect products under provisions of Division 01. Store components in clean, dry place. Protect from weather, dirt, water, construction debris, and physical damage.
1.10 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 210500 for additional warranty and Substantial Completion requirements.

C. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All products to be commercial grade, new and of the manufacturer’s latest design model. All material, equipment, and apparatus shall be identified by the manufacturer’s name, nameplate, and pertinent data.

1. All pipe, pipe fittings and valves shall be manufactured in North America, or may be import products where manufacturers are specifically identified below. Alternatives may be acceptable, but must be submitted and approved by the Owner’s Representative prior to bidding.

OR

2. Upon request, the Owner’s Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

B. All products to be UL listed and/or FM approved, except for items, which are not required to be listed by code.

C. All products shall be delivered and stored in original containers. Containers shall be clearly marked or stamped with manufacturer’s name and rating.

D. The following items to be included but specified under Section 210500: Basic Fire Protection Materials and Methods.

1. Hangers and supports.
2. Escutcheons plates, flashings and sleeves.
3. Access panel and doors.
4. Identification markers and signs.
5. Expansion compensators and flexible connectors.
6. Anchors, and seismic restraints.
7. Excavation and backfill.

2.2 SPRINKLER HEADS - GENERAL

A. Sprinkler heads shall be regular automatic closed-type heads of ordinary degree temperature rating except that sprinkler heads installed near the heating equipment or in special occupancy areas shall be of the temperature rating as described in NFPA-13.
B. Provide quick response heads in all new light hazard occupancies.

C. For existing sprinkler systems, provide sprinkler heads with response type to match existing type unless otherwise noted.

D. Provide corrosion-resistant sprinkler heads where they are exposed to weather, moisture or corrosive vapors.

E. The Contractor shall furnish spare heads. The heads shall be packed in a suitable container and shall be representative of, and in proportion to, the number of each type and temperature rating head installed. In addition to the spare heads, the contractor shall furnish not less than two special sprinkler head wrenches. Refer to NFPA 13 section; "Stock of Spare Heads".

F. Provide escutcheon and minimum 1/4" clearance around penetrations through suspended ceilings per ASCE requirements.

G. Sprinkler heads installed shall be upright or pendent, as conditions require, and shall be of the following type and finish for the areas designated. Unless otherwise specified, sprinklers shall be small frame type, center bulb capsule for finished areas, fusible link for unfinished areas, and 1/2" orifice. Extended coverage heads not allowed in unfinished areas except garages.

H. Sprinkler heads shall have a standard or large orifice K-Factor of 5.6 or 8.0. Sprinkler heads shall be UL Listed and FM Approved.

I. Manufacturers: Viking, Tyco, Anvil, Reliable, Globe, Victaulic, Venus or equal. Viking models shown as basis of design.

J. Sprinkler head requirements for each area as follows:

<table>
<thead>
<tr>
<th>BUILDING AREA</th>
<th>SPRINKLER HEAD STYLE</th>
<th>SPRINKLER HEAD FINISH</th>
<th>ESCUTCHEON FINISH</th>
<th>TEMPERATURE RATING (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfinished Space, Exposed Ceiling Retail, Exposed Ceiling Office, Parking Structure, Mechanical Rooms</td>
<td>Upright/Pendant</td>
<td>Brass</td>
<td>None</td>
<td>155°F</td>
</tr>
<tr>
<td>Electrical, Switchgear, IDF/MDF, Telephone Equipment, and Computer Equipment Rooms without finished ceilings.</td>
<td>Upright</td>
<td>Brass</td>
<td>None</td>
<td>286°F</td>
</tr>
<tr>
<td>Finished Ceilings</td>
<td>Semi-recessed Pendant</td>
<td>White</td>
<td>White</td>
<td>155°F</td>
</tr>
<tr>
<td>Finished Ceilings in Conference Rooms and Lobbies</td>
<td>Concealed Pendant</td>
<td>Brass</td>
<td>White Cover Plate</td>
<td>155°F</td>
</tr>
<tr>
<td>Soffit &amp; Sidewall</td>
<td>Flush Sidewall</td>
<td>White</td>
<td>White</td>
<td>155°F</td>
</tr>
<tr>
<td>Exterior Balconies &amp; Overhangs</td>
<td>Dry Sidewall</td>
<td>Brass</td>
<td>Chrome</td>
<td>175°F</td>
</tr>
<tr>
<td>Grease Exhaust Duct</td>
<td>Standard Pendant</td>
<td>Electroless Nickel PTFE (ENT)</td>
<td>None</td>
<td>360°F</td>
</tr>
</tbody>
</table>
K. Quick response sprinkler heads for dry systems, preaction systems and areas subject to freezing:
   1. Upright in exposed areas: Viking #VK184 (K Factor: 5.6)
   2. Pendent in exposed areas with no ceilings. Viking #VK186 (K Factor: 5.6)
   3. Pendent in exposed areas with ceilings. Viking #VK196 (K Factor: 5.6)
   4. Sidewall: Viking #VK188 (K Factor: 5.6), #VK284 or #VK288 or #VK292 (K Factor: 8.0)
   5. Sidewall for extra hazard Standard Coverage Viking #VK2923 (K Factor: 5.6)
   6. Standard Coverage Pendent in exposed area with ceiling Standard Coverage Flush Pendent Viking #VK482 (K Factor: 5.6)

2.3 PIPE AND FITTINGS - ABOVE GROUND

A. General: The piping products listed below by manufacturer's name and model numbers are the only acceptable materials listed for this project. Substitutions of pipe must be submitted and approved in writing by the Owner's Representative prior to bid.

B. Piping and fittings shall be new and clean prior to installation. Piping or fittings that show substantial rust or breaks in coating will be removed and replaced.

C. Steel Pipe and Fittings for wet systems:
   1. All steel pipe material shall be corrosion-resistant with a black enamel coating or other corrosion-resistant coating with a corrosion resistance ratio (CRR) of 1 or more.
   2. Schedule 40, Standard Weight, Black-Steel Pipe: ASTM A53/A53M. Pipe ends may be factory or field formed to match joining method.
   3. Schedule 30, Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30. Pipe ends may be factory or field formed to match joining method.
   4. Thinwall Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
   5. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 for sizes NPS 5 (DN 125) and smaller; and NFPA-13 specified wall thickness for sizes NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
   6. Stainless Steel Pipe, Schedule 10S or 40S: Manufactured and installed per ASTM A312/A312M.
      a. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
      b. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
      c. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Flange Flanges: Ring-type gaskets.
      d. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
      e. Mechanical type flange fittings or joint restraint systems are not acceptable.
b. Shop fabricated Bonney Forge “Weldolet" or “Thredolet" type fittings may be used in lieu of tee fittings, but field (site) welding will not be permitted.

15. Grooved-Joint, Steel-Pipe Appurtenances:
   a. Pressure Rating: 175-psig (1200-kPA) minimum, and as required by the design.
   b. Painted or Uncoated Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
   c. 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.
   d. Grooved joint couplings shall consist of two ASTM A 536 ductile iron housings, pressure-responsive, synthetic rubber gasket, and plated steel bolts and nuts.
      1) Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with NFPA 13. Tongue and recess rigid type couplings shall only be permitted if the contractor uses a torque wrench for installation. Required torque shall be in accordance with the manufacturer’s latest recommendations.
   e. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
   f. Use rigid type couplings where installation flexibility is not required.
   g. Mechanical Couplings: Victaulic grooved couplings style 07, 75 or 77, or equal by Gruvlok.

D. Copper Tube and Fittings for wet systems
1. Solder or brazed joints are NOT allowed for any copper tubing or piping systems
2. Mechanical pressed or grooved type joints shall be used for copper tubing and piping joints and fittings.
3. Seamless copper tube, pipe sizes up to 8”:
   a. ASTM B88, Type K or L, hard temper. Type M is not allowed.
      a. Manufacturers: Mueller Streamline, Cerro Flow Products, or equal.
4. Mechanical Grooved Couplings and Fittings:
   a. Standard: UL 213
   b. Grooved-End Copper Fittings: ASTM B76 copper tube or ASTM B584 bronze castings.
      c. Manufacturers: Victaulic, Anvil, or equal.
5. Mechanical Pressure-Seal-Joint Couplings and Fittings:
   a. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end.
   b. Minimum 200 psig working pressure.
      c. Manufacturer: Viega or equal.

E. Dry Standpipe, Dry Sprinkler and Preaction Sprinkler Piping and Fittings:
1. All steel pipe material shall be corrosion-resistant with a black enamel coating or other corrosion-resistant coating with a corrosion resistance ratio (CRR) of 1 or more.
2. Schedule 40, Standard Weight Black-Steel Pipe: ASTM A53/A53M. Other pipe materials will not be accepted for these applications.
3. Pipe ends may be factory or field formed to match joining method.
4. Rolled groove fittings are not allowed in a dry or preaction sprinkler system per Factory Mutual.

F. Flexible sprinkler connector for ceiling adjustability, seismic accommodation, and ductwork sprinkler applications. Stainless steel flexible braided tubing, Factory Mutual approved, and compatible with FM and UL sprinkler heads. Rated working pressure to 175 psi. Hose
lengths up to 72” maximum. Manufacturers: Flexhead (Anvil), Viking, Victaulic #VicFlex, or equal.

G. Dielectric Fittings:
1. Dielectric Waterways/Nipples:
   a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
   b. Comply with standard IAPMO PS 66.
   c. Electroplated steel waterway/nipple complying with ASTM F1545 or ASTM F492.
   d. Pressure Rating: 300 psig (2070 kPa) at 225°F (107°C).
   e. End Connections: Male threaded or grooved.
   f. Lining: Inert and noncorrosive, propylene.
   g. Manufacturers: Mifab #MI-DE Series, Victaulic #Series 647, or equal.

2. Dielectric Flanges:
   a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
   b. Comply with standard ASSE 1079.
   c. Factory-fabricated, bolted, companion-flange assembly.
   d. Pressure Rating: 125 psig (860 kPa) minimum at 180°F (82°C).
   e. End Connections: Solder or brazed joint copper alloy and threaded ferrous; or threaded solder-joint copper alloy and threaded ferrous.
   f. Dielectric-Flange Insulating Kits:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Gasket: Neoprene or phenolic.
      3) Bolt Sleeves: Phenolic or polyethylene.
      4) Washers: Phenolic with steel backing washers.
   g. Manufacturers: Watts #LF3100 Series or equal.

H. Piping and Fittings – Not Allowed:
1. Galvanized steel piping is not allowed due to corrosion potential. However, with pre-approval prior to bid, the use of galvanized steel in a dry or preaction system may be proposed when connected to a nitrogen source as a supervisory gas.
2. Copper pipe with soldered or brazed joints and fittings.
3. Pipe that is lighter gauge than Schedule 30 steel with threaded fittings is not allowed.
4. Schedule 5 piping and fittings are not allowed.
5. Threadable lightwall pipe is not allowed.
6. Mechanical “gripping teeth” type fittings are not allowed.
7. Mechanical “clamping” type tee fittings are not allowed.
8. Quick disconnect, boltless, snap-joint, field drilling or welding of any main or branch lines, and any device specifically prohibited by the local authority having jurisdiction is not allowed.
9. Unions are not allowed for any size pipe.
10. Plain end fittings are not allowed.

2.4 RODS AND CLAMPS

A. Socket clamps shall be stainless steel; four bolt type, equipped with stainless steel socket clamp washers and nuts. Manufacturers: Grinnell Fig. 595 and 594, Elcen Fig. 37 and 37X, or equal.

B. Rods shall be stainless steel, 3/4" diameter.
2.5 VALVING

A. 2" or Smaller:
   1. Control Valve: OS&Y rising stem type gate or globe valve, bronze body, bonnet and disc, copper alloy stem, threaded ends, 175 psig WOG min. Provide with tamper switch.
   2. Check Valve: Swing check type with bronze body, cap and disc, threaded ends, 175 psig WOG min.
   3. Drip Valve: 3/4", cast brass automatic ball drip type, threaded ends, 175 psig WOG min.
   4. Testing Valve: 1-1/4", test and drain, sight glass, 1/2" test orifice, lever operated, 300 psi WOG. Drain to mop sink or drain riser.
   5. Main Drain Valve: 2", angle gate valve, bronze body, copper alloy stem, threaded ends, 175 psi WOG. Drain to mop sink or drain riser.
   6. Manufacturer: Grinnell, Victaulic, Stockham, Milwaukee, Mueller, Nibco, United Brass Works, Kennedy, Elkart or AGF.

B. 2-1/2" or Larger:
   1. Control Valve: Grooved butterfly valve with tamper switch, ductile iron body, aluminum bronze disc, stainless steel stem and EPDM Liner, 200 psig WOG min, Victaulic 700.
   2. Control Valve: OS&Y rising stem type gate valve, cast iron body and bonnet, bronze stem, seat and disc, flanged ends, 175 psig WOG min. Provide with tamper switch.
   3. Check Valve: Swing check type with cast iron body, bolted cap and disc, flanged or grooved ends, 175 psig WOG min.
   4. Manufacturer: Grinnell, Victaulic, Stockham, Milwaukee, Mueller, Nibco, Kennedy, Elkart or AGF.

2.6 EXPANSION LOOPS

A. Flexible Expansion Joint/Seismic Connector for Steel Pipe: Stainless steel hose and braid, carbon steel 180° return, UL and FM approved, and grooved or welded end fittings. Maximum 4" movement in all directions. Provide steel supports to prevent sagging as required. Manufacturers: Metraflex #Fireloop MLUGFM series or equal.

2.7 WET SPRINKLER ALARM CHECK VALVE

A. Contractor shall provide, where required, a completely engineered horizontal wet alarm check valve, retarding chamber, and trim assembly. Viking #H-2, Star or Reliable.

2.8 VALVE BOXES

A. Cast iron valve boxes for shutoff valves buried in ground shall be complete with bellbottoms, extension piece, top and cover. Boxes shall be suitable for the types of valves with which they are used. All valve boxes shall have a concrete collar flush with grade.

B. Lids shall have the applicable letters embossed upon the top surface. Tagging shall match existing lids.

C. Manufacturers: Tyler, ITT Grinnell, or equal.

2.9 INTEGRAL INSPECTORS ALARM TEST AND SYSTEM DRAIN

A. Combination system alarm test module with drain and visible orifice insert/sight glass for testing system alarm:
   1. Threaded or grooved inlet and outlet connections.
   2. Bronze body.
3. Malleable iron hand wheel.
4. EPDM valve seats.
5. Maximum working pressure 300 psi.
6. Test port orifice sizes: K5.6 or K8.0.
7. FM listed.
8. 1/2” pressure relief valve, 175 psi rating.
9. Alarm test module manufacturer: Victaulic TestMaster II #Serie 720 or equal.
10. Pressure relief valve manufacturer: Watts Regulator #FP 53L or equal

B. Water pressure gauge, range 0-300, in 5 psig increments, brass case, 3-1/2” diameter (minimum), 1/4” NPT male pipe connection, UL listed. Locate pressure gage on riser per code. Manufacturer: Star Sprinkler, Ashcroft or equal.

C. Pressure gauge test valve, brass 1/4” screwed ends, 300 psig WOG. Manufacturer: United or equal.

D. All relief, main, auxiliary and equipment drain piping shall be routed separately to floor sink(s) or other approved locations. Coordinate with plumbing design for location of floor sinks or other approved drain locations.

2.10 TAMPER SWITCHES

A. Switch shall be mounted so as not to interfere with normal operation of the valve and be adjusted to operate when handle of valve has traveled more than one-fifth the distance of its normal operating position. Electrical Contractor shall provide conduit from switch to fire alarm panel.

B. Housing shall be of aluminum, acid-treated, primed and finished in baked red enamel. Removal of housing shall cause switch to operate. Inside shall be single pole, double throw micro switch with connection for electrical conduit.

C. Install on all control valves.

D. Manufacturer: Potter Electric, Notifier, Ellenco, Simplex, or equal.

2.11 WATER FLOW ALARM - VANE TYPE

A. Indicator shall be for either vertical or horizontal installation. Indicator shall not be installed in a fitting that changes direction of water flow and shall have a sensitivity setting to signal any flow of water that equals or exceeds the discharge from one sprinkler head. Provide retarding device to prevent false alarms from line surges.

B. Whenever a water flow alarm is installed in the piping system, an approved floor control valve shall be provided upstream of the alarm indicator. In addition, a drain is required downstream of the alarm indicator.

C. Each water flow alarm shall be wired to a Fire System. All wiring and conduits as required will be provided under Division 26. An alarm will automatically activate the local fire alarm system.

D. Manufacturer: Potter Electric Signal Company, Notifier, Simplex, or equal.

2.12 AUTOMATIC MAIN LINE AIR VENT

A. Automatic in-line air vent with enlarged air collection chamber.
B. Pressure Rating: 300 psig (2070 kPa) minimum.

C. Separation Chamber:
   1. Carbon steel body with threaded fitting for cast bronze air scoop attachment.
   2. Powder coated safety red color.
   3. Inlet and outlet size to match sprinkler pipe line sizes with grooved ends.

D. Automatic Air Vent Valve:
   2. Components: Integrated ball valve, stainless steel strainer, purge valve with hose connection, threaded cap with lanyard, automatic air vent.
   3. Inlet Size: 1-inch NPT.
   4. Outlet Size: 3/4-inch NPT.
   5. Drainage Piping: Field provided 1/2 to 3/4 inch copper tubing for discharge of the automatic air vent valve and route to approved plumbing receptacle or to the exterior landscaping.

E. Manufacturer: AGF Manufacturing PURGEnVENT #7950ILV or equal.

2.13 MANUAL BRANCH LINE AIR VENT

A. Pressure Rating: 300 psig (2070 kPa) minimum.

B. Manual Air Vent Valve:
   2. Components: Integrated ball valve, stainless steel strainer, purge valve with hose connection, threaded cap with lanyard, polypropylene float.
   3. Inlet Size: 1/2-inch NPT.
   4. Outlet Size: 1/2-inch NPT.

C. Manufacturer: AGF Manufacturing PURGEnVENT #7910MAV or equal.

2.14 EXTERIOR ALARM

A. Electric bell, 8” or 10” diameter, UL listed, weatherproof backbox housing. Minimum dB ratings per UL Standard 464. Indoor or outdoor use from -40°F to 150°F (-40° to 66°C). 24 or 120 volt as required by fire alarm design. Manufacturer: Potter Electric Signal Company #PDC or PBA series, Notifier, Simplex, or equal.

B. Electric Horn: Weatherproof with backbox, indoor or outdoor use, horn and strobe, 120 VAC. Manufacturer: Potter Electric Signal Company, Notifier, Simplex, or equal.

2.15 FIRE HOSE CABINETS

A. Refer to Architectural and Mechanical Drawings for exact location and elevations.

B. Cabinets shall be recessed, semi-recessed, or surface mounted as indicated on Architectural Drawings. Cabinets shall be 20-gauge steel construction, 28” wide by 39” high by 8” deep overall dimensions with full glass door panel, identifying decal, and gray enamel factory prime finish. All components shall have a rough chrome finish. Provide with the following:
   1. 1-1/2” stamped valve escutcheon.
   2. 2-1/2” angle valve.
   3. Baked enamel steel hose rack.
   4. 1-1/2” brass rack nipple.
5. 1-1/2" x 100'-0" of single jacket polyethylene lined hose.
6. Cast brass couplings.
7. Fog nozzle.

C. Manufacturer: Croker, Larsen’s J & L or Potter-Roemer.

2.16 FIRE DEPARTMENT VALVE CABINETS

A. Refer to Architectural and Mechanical drawings for exact location and elevation of each cabinet.

B. Cabinets shall be 18" x 18" inside box dimensions, recessed, 20-gauge steel with full glass door and 2-1/2" fire department valve with rough chrome finish. Cabinets shall have a factory prime finish.

C. Manufacturer: Crocker, Larsen’s J & L or Potter-Roemer.

PART 3 EXECUTION

3.1 GENERAL

A. This system to be installed by an experienced firm regularly engaged in the installation of automatic sprinkler system as specified by the requirements of the Specifications.

3.2 PERFORMANCE OF WORK

A. Examine areas and conditions under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings and in accordance with NFPA 13, 14, 20 and 24.

B. Work to start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed.

C. Coordinate with other trades as necessary to properly interface components of the sprinkler system.

D. Follow manufacturer's directions and recommendations in all cases.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.3 TEMPORARY FIRE PROTECTION

A. Provide all temporary valving, piping, Siamese connections and other components as directed by the fire agency office during all phases of construction.

3.4 INSTALLATION-GENERAL

A. Fire protection system shall be installed in accordance with the approved Drawings. The finished ceiling is not to be erected until all fire protection piping has been installed, tested, and inspected. Sprinkler heads located in the electrical equipment, elevator machine, or similar rooms shall be furnished with deflectors to prevent water spray on equipment.
B. Underground piping shall be permitted to extend into the building through the slab or wall no more than 24 inches (600 mm). In locations where freezing is not a factor, the depth of cover shall not be less than 30 inches (750 mm) below grade to prevent mechanical damage. In addition, in freezing environments shall be buried not less than 12 inches (300 mm) below the frost line for the locality. Pipe joints shall not be located under building foundation. Piping shall be installed a minimum of 12 inches (300 mm) below the bottom of building foundation or footers.

C. Before connection to the overhead piping, all underground piping shall be flushed with water flowing at velocity and quantity required by the installation standards specified above in this Section of the Specifications.

D. The arrangement of all pipes shall conform to all architectural requirements and field conditions, shall be as straight and direct as possible, forming right angles or parallel lines with building walls and other pipes, and shall be neatly spaced. Offsets will be permitted only where required to permit the pipes to follow the walls. Standard fittings shall be used for offsets. All risers shall be erected plumb and true, shall be parallel with the walls and other pipes, and shall be neatly spaced. All work shall be coordinated with HVAC, Plumbing, Electrical and Structural work in order to avoid interference and unnecessary cutting of floors or walls. All underground or concealed work shall be inspected before the construction is closed up.

E. All sprinkler heads to be installed in ceilings throughout the scope of work building as listed in Part 2 sections. All areas without ceilings shall have rough brass upright or pendant heads.

F. Sprinkler heads in all finished areas are to be installed on a true axis line in both directions, with maximum deviation from the axis line of 1/2-inch plus or minus and shall be plus or minus 1" within center of tile. At the completion of the installation, if any heads are found to exceed the above-mentioned tolerance, they shall be removed and reinstalled.

G. No pipes or other apparatus shall be installed so as to interfere in any way with full swing of doors.

H. The arrangement, positions, and connections of pipes, drains, valves, etc., shall be as required by NFPA-13 for all areas requiring sprinklers. At all low points provide drains and provide drains or capped tees fittings at isolated low points in the piping system. However, the right is reserved by the Owner’s Representative to change the location of any item to accommodate conditions, which may arise during progress of the work, without additional compensation for such changes provided that no additional heads are required prior to the installation of the work.

I. Where required, piping shall be installed concealed in building construction, or though steel beams, to obtain adequate head room.

J. All pipe throughout the job shall be reamed smooth before being installed. Pipe shall not be split, bent, flattened, or otherwise injured either before or during installation.

K. Provide protective pans under pipes passing over high voltage electrical bus duct or switchgear equipment. The pan shall be constructed of 22-gauge black iron with a 6-inch lip, the corners being welded to make the pans watertight. Each pan shall be given two coats of gray primer paint and shall be supported by pipe hangers. The pan shall drain clear of the bus duct or switchgear.
L. All pipe interiors shall be thoroughly cleaned of foreign matter before installation, and shall be kept clean during installation by plugging or other approved means. Piping shall be covered with waterproof plastic sheeting during storage. Piping that shows signs of rusting will be removed from job site and replaced.

M. Field Connections: Any modifications to system required by field conditions, physical equipment changes or compliance with code regulations shall be made promptly without cost to Owner.

N. Interference: No piping or sprinkler devices shall interfere with the operations of any door, window, or mechanical and/or electrical systems. No part of this system shall visibly installed in the physical parameter of any window.

O. Threaded Pipe: Threads shall be clean cut, standard and tapered. Threads shall be made up using flaked graphite and lubricating oil, piping compound or Teflon tape applied to the male threads only.

P. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be molded and produced by the same manufacturer. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

Q. Keep all pipe and other openings closed to prevent entry of foreign matter. Cover all equipment and apparatus to protect against dirt, water, chemical or mechanical damage, before and during construction period. Restore to original condition all apparatus and equipment damaged prior to final acceptance, including restoration of damaged shop coats of paint.

R. Location of sprinkler piping is critical.
   1. Where ceiling space is at a minimum under beams location of ductwork takes precedence, coordinate accordingly.
   2. Include in base bid, multiple coordination meetings, as required with Owner’s Representative for coordination of sprinkler pipe routing, at no additional cost to the Owner.
   3. Coordinate beam and shear wall penetrations with Structural Engineer. Obtain written approval for all beam penetrations from Structural Engineer.

S. Tracer wire shall be wrapped and taped to non-metallic underground piping at maximum 20-foot intervals.

3.5 INSTALLATION-MAIN DRAIN TEST CONNECTIONS

A. Provide and install all drain piping associated with fire protection systems as required by NFPA-13, Chapter 8. Minimum drain riser size shall be 2-1/2” diameter, or larger, as required by quantity of connections to riser.
B. Coordinate location of floor sinks and sizing with plumbing design prior to installation of fire protection or plumbing piping. Fire protection contractor will be responsible for any revisions to other trades due to lack of fire protection coordination.

C. Drain piping shall be provided and installed by fire protection installer. Drains shall discharge outside or to a drain connection capable of handling the flow of the drain. Where possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage.

D. Main drain test connections shall be provided at locations that will permit flow test of water supplies and connections.

E. Where drain connections for floor control valves are tied into a common drain riser, the drain riser shall be one pipe size larger downstream of each size drain connection typing into it.

F. Where exposed drain pipes terminate provide turned-down elbow and terminate with a minimum air gap of two times the drain pipe diameter.

G. Drain pipes shall be arranged to avoid exposing any of the water-filled portion of the sprinkler system to freezing conditions.

H. Provisions should include vents at the top of drain riser including a check valve to allow air into the drain riser.

3.6 WELDING

A. Conform to welding procedures per recommendations of American Welding Society.

3.7 THRUST BLOCKS

A. Provide thrust blocks at changes in pipe direction, changes in pipe sizes, dead-end stops and at valves.

B. Calculate area of undisturbed earth of thrust block based on actual soil conditions and water test pressure of 200 psi.

C. Concrete and reinforcing steel shall be as specified in Division 03 and 05. All concrete shall be Class A, unless specified otherwise.

D. Miscellaneous nuts and bolts shall be stainless steel.

3.8 SLEEVES AND FLASHINGS

A. Wherever pipes are exposed and pass through walls, floors, partitions or ceilings, they shall be fitted with chromium plated steel escutcheons held in place with setscrews. Care shall be taken to protect the escutcheons during the course of construction.

B. Penetrations through fire rated walls and floors shall be sealed with listed mastic of similar fire rating.
3.9 HANGERS, INSERTS, SUPPORTS, AND SWAY BRACING

A. Hangers and supports shall be installed per NFPA-13 sections on Hangers and Protection of Piping Against Damage Where Subject to Earthquake. Provide restraint from movement at end sprinkler on branch line per NFPA-13.

B. Bending of threaded hanger rod is not allowed. Powder driven anchor pins in concrete are not allowed.

C. Upgrade existing end sprinklers on branch line with new restraint from movement device.

3.10 EXPANSION LOOPS AT EXPANSION JOINTS

A. Provide flexible hose expansion loop(s) as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction, building settlement, or seismic movement of the piping system.

B. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal house, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.

C. Flexible loops shall be capable of movement in the ±X, ±Y, and ±Z planes to meet or exceed the limits identified in the structural design.

D. Flexible hose expansion loops shall impart no thrust loads to system support, anchors or building structure.

E. Provide pipe anchors and pipe alignment guides as indicated, and elsewhere as determined by installer to properly anchor piping in relationship to expansion loops.

3.11 MANUAL AND AUTOMATIC AIR VENTING

A. Install manual and automatic air venting to remove trapped air every time system is filled and as required by NFPA-13 and local AHJ and as recommended by Factory Mutual guidelines. Air vents shall be installed at the high points in the piping system. The objective of venting is to reduce the amount of oxygen trapped in the system that will support corrosion and microbial activity.

B. Install an automatic in-line air vent at each high point in the system to allow air to be removed automatically from the metallic pipe system. Provide copper drainage tubing, minimum 1/2” diameter, on the discharge of the automatic air vent valve and route to approved plumbing receptacle or to the exterior landscaping.

C. Install manual in-line air vents at the end of each branch line, at the most remote point from the riser, and at the top of the supply risers to eliminate as much air as possible to minimize internal pipe corrosion.

3.12 SAFETY TESTING & VERIFICATION

A. Flush, test, and inspect sprinkler piping systems according to NFPA-13 Chapter “System Acceptance” and refer to Factory Mutual FMDS0201 for guidelines on corrosion in sprinkler systems.

1. Chemical cleaning or water treatment shall not be provided. The introduction of a treatment solution into the sprinkler piping network with dead-end pipe runs and pendent
drops can result in a large variation of chemical concentrations which can accelerate corrosion and growth of microorganisms. Flushing of the system until water is clear and venting all air is the recommended method for maintaining sprinkler piping.

B. Provide NFPA-13 Contractor's Material & Test Certificate Form 85A for above ground piping and Form 85B for underground piping.

C. Provide manpower to test the function and performance of all Life Safety System components and devices per floor and per zone basis in accordance with the local requirements.

3.13 IDENTIFICATION

A. In addition to the requirements of Section 210500, provide engraved pipe markers every 20 feet, once in every room, and at each building level traversed, minimum. Text shall include riser and/or zone numbers to align with drawings and fire alarm panel.

B. Provide hydraulic design data nameplates (engraved text) on the riser of each sprinkler system in accordance with NFPA-13.

C. Equipment such as valves, drains, etc., shall be provided with signs that identify type of equipment and service. The tag shall be securely fastened to the handle or spindle of the valve by a brass chain. Furnish four schedules of valves so tagged. There shall also be furnished four diagrammatic charts showing schematically the complete sprinkler system with major control valves and numbers thereof. One set of Schedules and charts shall be mounted in glazed frames located where directed.

3.14 AS-BUILT RECORD DRAWINGS AND CERTIFICATION

A. As-built Record Drawings are to be kept up-to-date and the Master Copy kept at the job site. Prior to final acceptance of work being approved, these drawings are to be turned over to the Owner's Representative for approval.

B. Written certification from the insuring agents, and authorities having jurisdiction that the tests were satisfactory.

C. After installation is complete and tests satisfactorily approved, deliver test certificates and approval by the local Fire Authorities and the insurance company to the Owner’s Representative. Final acceptance of sprinkler/standpipe system by Owner’s Representative shall be contingent upon receipt of certificate and approval from authorities having jurisdiction and for the delivery of final Record Drawings.

3.15 INSPECTION, TESTING, AND MAINTENANCE

A. Where steel pipe is used in dry pipe and preaction systems, it shall be assumed that the water supplies and environmental conditions contribute to unusual corrosive properties.

B. A corrosion protection plan shall be developed to address steel piping corrosion in accordance with NFPA-13 and NFPA-25.

C. Sprinkler piping and fittings shall be inspected annually by the Owner’s Representative for signs of corrosion, leakage, and physical damage, in accordance with NFPA-25.
D. Inspection, testing, and maintenance activities shall be followed to determine that components are free of corrosion, foreign material, physical damage, tampering, or other conditions that adversely affect system operation.

E. An internal corrosion evaluation of system piping shall be conducted at intervals not to exceed five (5) years.

F. The evaluation shall include an internal inspection of the piping condition near the sprinkler riser and the opening of the flushing connection on a system main.

END OF SECTION
PART 1  GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and all Plumbing Sections specified herein.

1.2 SCOPE OF THIS SECTION

A. Work to be furnished and installed under this Section shall include, but not necessarily be limited to, the following:
   1. Compliance with all codes and standards applicable to this jurisdiction.
   2. Shop Drawings for Equipment
   3. Coordination Documents
   4. Record drawings
   5. Start-up and commissioning service
   6. Instruction, Training, and Operations & Maintenance Manuals
   7. Work associated with delivery, storage, and handling of products
   8. Work associated with provision of temporary facilities
   9. Preparation of posted operating instructions
   10. Meeting project safety and indemnity requirements
   11. Proper cleaning and closing
   12. Supplying proper Warranty information
   13. Supply specified Guarantee documentation
   14. Design and provision of supports and anchors
   15. Design and provision of seismic restraints
   16. Design and provision of vibration isolation
   17. Through-penetration and membrane penetration firestop assemblies
   18. Hangers and supports
   19. Pipe portals
   20. Pipe stands
   21. Equipment supports
   22. Access panels and doors
   23. Miscellaneous fixtures
   24. Identification markers, equipment labels, pipe labels, valve tags, warning signs.
   25. Coordination of electrical requirements for equipment provided

1.3 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to include all material and labor to install complete plumbing systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate the work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, and pipe lines and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.
D. Where project involves interface with existing building and/or site systems, existing utilities and services have been indicated on the drawings to the extent possible based on available record drawings. The Contractor shall thoroughly familiarize themselves with existing conditions and be aware that in some cases information is not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all plumbing system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The plumbing system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply plumbing devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

G. Refer to Basis of Design on drawings. Systems as specified under this section shall include, but not necessarily be limited to, the following:
   1. Connection to site utilities between two (2) and five (5) feet from the building as defined by local jurisdiction. Coordinate with the Civil Engineering design and plans.
   2. Connection of all waste, vent, and water piping to all plumbing fixtures, sinks, toilets, drinking fountains, sinks, water dispensers, drains and mechanical equipment.

1.4 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01. Submit manufacturer’s data, installation instructions, and maintenance and operating instructions for all components of this section including, but not limited to, the following:
   1. Supports and anchors
   2. Access panels and doors
   3. Identification markers, labels and tags
   4. Pipe portals
   5. Emergency showers and eye washes
   6. Plumbing specialties
   7. Roof flashing

B. Contractor shall submit a letter that all products used in the plumbing system are certified for use in the State and Municipality of the project site.

1.5 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
   1. Specifications, in general, describe quality and character of materials and equipment.
   2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:
   1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and details of installation.
   2. Before proceeding with work check and verify all dimensions.
3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
4. Make adjustments that may be necessary or requested, to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
5. Verify exact location and elevation of existing piping, ductwork, conduits and structure and coordinate to accommodate installation of new work as indicated on the drawings.
6. If any part of Specifications or Drawings appears unclear or contradictory, apply to the Owner’s Representative for interpretation and decision as early as possible, including during bidding period.

1.6 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.
B. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.
C. Below Grade: Buried in the ground or embedded in concrete slab on ground.
D. Building Drain: That part of the lowest piping of a drainage system that receives the discharge from soil, waste, and other drainage pipes inside the walls of the building and conveys it to the building sewer beginning 2 feet (610 mm) to 5 feet (1,524 mm) outside the building wall.
E. Building Sewer: That part of the horizontal piping of a drainage system that extends from the end of the building drain and that receives the discharge of the building drain and conveys it to a public sewer, private sewer, private sewage disposal system, or other point of disposal.
F. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.
G. Connect: Complete hook-up of item with required service.
H. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.
I. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements.
J. Exposed: Not installed underground or concealed.
K. Furnish: To supply equipment and products as specified.
L. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.
M. Install: To erect, mount and connect complete with related accessories.
N. Lead Free: Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining "weighted average".

O. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

P. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

Q. Noncombustible Material: A noncombustible material is a substance that will not ignite, burn, support combustion, or release flammable vapors when subject to fire or heat in compliance with ASTM E136 Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C. Examples of noncombustible materials include the following, but confirm compliance in manufacturer literature:
   1. Portland cement concrete, concrete, gypsum concrete (normally used in drywall or poured gypsum floor toppings), Portland cement stucco, Portland cement plaster, and gypsum plaster, gypsum wall board (sheetrock), and Type X gypsum wall board.
   2. Brick masonry, concrete block masonry, and ceramic tiles.
   3. Steel, stainless steel, galvanized steel, and other metals, except aluminum (aluminum is classified as limited-combustible), magnesium and magnesium alloys.
   4. Sheet glass, block glass, and uncoated glass fibers.

R. NRTL: Nationally Recognized Testing Laboratory, including UL, CSA and/or ETL.

S. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

T. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

U. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

V. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

W. Shall: An exhortation or command to complete the specified task.

X. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

Y. Supply: To purchase, procure, acquire and deliver complete with related accessories.

Z. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

AA. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

BB. Wiring: Raceway, fittings, wire, boxes and related items.
CC. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.7 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 22 Plumbing sections included herein.

B. Division 01: General Requirements
   1. Including commissioning requirements.

C. Division 03: Concrete.
   1. All concrete work required for plumbing work shall be coordinated by Division 22 with Division 03 including:
      a. Concrete curbs and housekeeping pads for the mechanical equipment.
      b. Thrust blocks, pads, and boxes for mechanical equipment.
      c. Coordination of floor drain and floor sink installations in sloped floors.

D. Division 07: Thermal and Moisture Protection.
   1. Flashing and sheet metal.
   2. Sealants and caulking.
   3. Firestopping.

E. Division 09: Finishes.
   1. Division 22 installers shall perform all painting, except where specifically stated otherwise in Division 09.
   2. Painting of all exposed steel, piping, insulation, equipment, and materials.
   3. All exposed gas piping located exterior to the building and as required by Authority Having Jurisdiction.

F. Division 21: Fire Suppression.
   1. Fire protection contractor to provide drain piping from fire suppression risers, inspector test locations and auxiliary drain locations to approved termination outside the building or other approved locations per NFPA-13.
   2. Coordinate required indirect plumbing drain location(s), floor sinks and/or hub drains, with fire protection design. Provide minimum 3” sanitary sewer to serve riser drainage, or as shown on the drawings.

G. Division 23: HVAC.
   1. Drain inlets and sanitary sewer piping to serve all condensate and equipment drainage from mechanical equipment.
   2. Coordinate plumbing piping and drain locations with HVAC drawings.
   3. Domestic water makeup water piping, valves and backflow prevention devices to serve mechanical equipment.

H. Division 26: Electrical.
   1. Power connections to all plumbing equipment.
   2. Life safety provisions.

1.8 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.
B. Perform all tests required by governing authorities and required under all Division 22 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

E. Provide in accordance with rules and regulations of the following:
   1. Washington Building Codes enforced by the Authority Having Jurisdiction (AHJ):
      a. 2015 International Building Code (IBC) with State Amendments
      b. 2015 International Mechanical Code (IMC) with State Amendments
      c. 2015 Uniform Plumbing Code (UPC) with State Amendments
      d. 2015 International Fire Code (IFC) with State Amendment
      e. 2015 National Fuel Gas Code (NFGC) NFPA 54, WAC 51-52
      f. 2015 Washington State Energy Code, (WAC 51-11, WSEC)
      g. 2017 National Electrical Code (NEC)
      h. Washington State Ventilation and Indoor Air Quality Code, WA 51-13 (VIAQ)
   2. Local jurisdiction codes and amendments
   3. Local utility requirements for water, sewer and gas provisions as appropriate
   4. State Fire Marshal Office
   5. Health Department
   6. State Administrative Codes

F. Provide in accordance with appropriate referenced standards of the following:
   1. ADA - Americans with Disabilities Act.
   2. ADC - Air Diffuser Council.
   4. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers.
   5. ASME - American Society of Mechanical Engineers.
   6. ASSE - American Society of Sanitary Engineers.
   8. AWS - American Welding Society.
   10. CISPI - Cast Iron Soil Pipe Institute.
   12. ETL - Electrical Testing Laboratories.
   13. FM - Factory Mutual.
   14. IAPMO - International Association of Plumbing and Mechanical Officials.
   15. MSS - Manufacturer's Standardization Society.
   16. NEMA - National Electrical Manufacturer's Association.
   18. PDI - Plumbing and Drainage Institute.
   20. UL - Underwriter's Laboratories.

G. Provide compliance in accordance with the following referenced standard which applies to general system compliance in contrast to specific equipment standards referenced elsewhere:
   1. UL-2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces. This is applicable to spaces above suspended ceilings and below raised floors.
1.9 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner’s Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Owner’s Representative for a decision before proceeding.

1.10 QUALITY ASSURANCE

A. Manufacturer’s Nameplates: Nameplates on manufactured items shall be affixed to each piece of equipment and resistant to ambient conditions.

B. All work shall include the following:
   1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.

C. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

D. Welding Standards:
   1. Welding Qualifications:
      a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner’s Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.
   2. Welding Procedures:
      a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
      b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.”

E. Pressure Piping Standards
   1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.
   2. Comply with ASME B31.9 Building Services Piping standard for the following services:
      a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
      b. Fluid pressure less than 350 psig.
3. Comply with ASME B31.3 Process Piping standard for the following services:
   a. Conveying fluid above 250°F (121°C).
   b. Toxic or flammable fluids.

F. Comply with minimum requirements in “Vents” chapter of local plumbing code including amendments from Authority Having Jurisdiction for termination height of vents above the roof due to localized frost and snow conditions.

1.11 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permits, licenses, fees and inspections.

D. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing without impacting adjacent equipment or piping. This work shall include furnishing and installing all access doors required for mechanical access. Joints and fittings shall not be located in inaccessible locations such wall, floor and roof penetrations.

E. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Coordinate all work with other disciplines before proceeding with installation.

F. Coordinate plumbing equipment and materials installation with other building components.

G. Piping dimensions, as identified on drawings and in specifications, refer to the interior free dimensions. Adjust work as necessary to account for larger outside dimensions to account for material wall thickness.

H. Verify all dimensions by field measurements.

I. Arrange for chases, slots, and openings in other building components to allow for plumbing installations.

J. 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.

K. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor to provide for all cutting and patching required for installation of his work unless otherwise noted.

L. Where mounting heights are not detailed or dimensioned, install plumbing services and overhead equipment to provide the maximum headroom possible.

M. Install plumbing equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.
N. Coordinate the installation of plumbing materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

O. Coordinate connection of plumbing systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

P. Coordinate with Owner’s Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

Q. All materials (such as insulation, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method and UL-2043.

R. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

S. Pipes, pipe fittings, plumbing fittings and fixtures that come into contact with the wetted surface of a public water system or any plumbing in a facility providing water for human consumption shall be “Lead Free”.

1.12 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all plumbing work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting the work. The contractor’s scope of work shall include
   1. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications
   2. Minor deviations from the plumbing plans required by architectural and structural coordination.

C. The Contractor shall study the operational requirements of each system, and shall arrange the work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems within the physical space available for use by this section. This requirement extends to the Contractor’s coordination of this section’s work with the “Electrical Work.” Should conflicts occur due to lack of coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

D. Minor deviations in order to avoid conflict shall be permitted where the design intent is not altered.

E. Advise the Owner’s Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.
1.13 PRODUCT SUBSTITUTIONS

A. Coordinate all substitution requests with requirements of Division 01 work. The Contractor shall certify the following items are correct when using substituted products other than those scheduled or shown on the drawings as a basis of design:
   1. The proposed substitution does not affect dimensions shown on drawings.
   2. The Contractor shall pay for changes to building design, including engineering design, detailing, structural supports, and construction costs caused by proposed substitution.
   3. The proposed substitution has no adverse effect on other trades, construction schedule, or specified warranty requirements.
   4. Maintenance and service parts are available locally and readily obtainable for the proposed substitute.

B. The Contractor further certifies function, appearance, and quality of proposed substitution are equivalent or superior to specified item.

C. The Contractor agrees that the terms and conditions for the substituted product that are found in the contract documents apply to the proposed substitution.

1.14 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Provide submittals for all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer's Certified Drawings to the Owner's Representative for review and approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer's equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Submittals and Shop Drawings:
   1. Submit electronic copies of manufacturer's submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner’s Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
   2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
   3. Paper submittals will only be acceptable if specifically required by Division 01.
   4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.

1.15 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.
   1. The shop drawings shall serve to record the coordination of the installation and location of all piping, fixtures, HVAC equipment, ductwork, grilles, diffusers, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
   2. The Drawings shall include all mechanical rooms and floor plans.
   3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall
coordinate the proposed installation with the Owner’s Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner’s Representative.

4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:

1. Two dimensional AutoCAD / Revit based documents:
   a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4" = 1'-0" or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8" high.
   b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Plumbing drawings shall indicate locations of all fixtures and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Drawings shall incorporate all addenda items and change orders.
   f. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

2. Three dimensional Revit / BIM based documents (if required for project):
   a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
   c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
   d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
   e. Model shall incorporate all addenda items and change orders.
   f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner’s Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.
D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

1.16 REQUESTS FOR INFORMATION (RFIS)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
   1. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.
   2. RFIs shall address single questions and related issues only.
   3. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
   2. Project number.
   3. Date.
   4. Name of Contractor.
   5. Name of Architect and Construction Manager.
   6. RFI number, numbered sequentially and unique.
   7. RFI subject.
   8. Specification Section number and title and related paragraphs, as appropriate.
   9. Drawing number and detail references, as appropriate.
   10. Field dimensions and conditions, as appropriate.
   11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
   12. Contractor's signature.
   13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
      a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.
   1. The following Contractor-generated RFIs will be returned without action:
      a. Incomplete RFIs or inaccurately prepared RFIs.
      b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
      c. RFIs addressing multiple unrelated issues.
      d. Requests for approval of submittals.
      e. Requests for approval of substitutions.
      f. Requests for approval of Contractor's means and methods.
      g. Requests for information already indicated in the Contract Documents.
h. Requests for adjustments in the Contract Time or the Contract Sum.

i. Requests for interpretation of Engineer’s actions on submittals.

2. Engineer’s action may include a request for additional information, in which case Engineer’s time for response will date from time of receipt of additional information.

1.17 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked “Record Set” at the job site at all times, and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping, size and location both exterior and interior; including locations control devices, and equipment requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. At the completion of the construction transfer all "Record Set" notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

E. Refer also to Division 01 for full scope of requirements.

1.18 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Contractor shall submit to the Owner’s Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section.

B. The Contractor shall be responsible for proper instruction of Owner’s personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 22, to be no less than two (2) hours for each type of equipment.

C. Refer to Division 01 for additional requirements.

1.19 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with manufacturer’s names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment that is damaged or showing signs of rust shall be removed from site and replaced with new.
1.20 TEMPORARY FACILITIES

A. Refer to Division 01 for the requirements of temporary water and sewer for construction and safety. Provide temporary water, and sewer, etc. services as necessary during the construction period and as required to maintain operation of existing systems.

1.21 UNIT PRICING SUBMITTALS

A. Prior to construction submit for review all materials and equipment and pricing in accordance with Division 01 requirements.

1.22 POSTED OPERATING INSTRUCTIONS

A. Print or engrave operating instructions and frame under glass or UV resistant plastic. Post instructions as directed by Owner's Representative. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.23 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work for the duration of the project.

B. No act, service, Drawing, review, or Construction Review by the Owner, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor's safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor's negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.24 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner's Representative.

1.25 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.
B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.26 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after the Certificate of Occupancy, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers' names used herein, unless specifically noted that substitutes are not allowed.

C. All materials and equipment under this Division of the Specifications shall be new, of best grade and as listed in printed catalogs of the manufacturer.
D. All manufactured materials shall be delivered and stored in their original containers. Equipment shall be clearly marked or stamped with the manufacturer's name and rating.

E. For secure facilities, schools and public safety buildings exposed equipment and access shall be Vandal Proofed. One type of vandal proof screw is to be used throughout this facility. Coordinate with General Contractor for type.

F. The following products to be included as part of this work but specified under Section 220500 Basic Plumbing Materials and Methods and Section 221000 Plumbing Piping, Valves and Specialties:
   1. Piping.
   2. Valves.
   3. Hangers and supports.
   4. Escutcheon plates, flashings, and sleeves.
   5. Identification markers and signs.
   6. Anchors and alignment guides to comply with seismic requirements as indicated on structural plans.
   7. Excavation and backfill.
   8. Pressure and temperature gauges.

G. Products made of, or containing, lead, asbestos, mercury, or other known toxic or hazardous materials are not acceptable for installation under this Section. Any such products installed as part of the work of this Section shall be removed and replaced and all costs for removal and replacement shall be borne solely by the Contractor(s).

2.2 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:
   1. UL: Provide products which are UL listed.
   2. FM: Provide products which are FM approved.
   3. ASCE 7-05: “American Society of Civil Engineers.”
   4. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
   6. NFPA: Pamphlet number 13 and 14 for fire protection systems.
   7. Provide copper plated or plastic coated supports and attachments for copper piping systems. Field applied coatings or tape is unacceptable.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS types listed.
   1. Adjustable Steel Clevis Hangers: MSS Type 1.
   2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
   4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
      a. Plate: Unguided type.
      b. Plate: Guided type.
      c. Plate: Hold-down clamp type.
   5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
   6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
8. Upper Attachment Side Beam Bracket: MSS Type 34
9. Upper Attachment Side Beam Angle Bracket: MSS Type 34, UL listed and FM Approved.
10. Single Pipe Roller with Malleable Sockets: MSS Type 41.
11. Adjustable Roller Hangers: MSS Type 43.
12. Pipe Roll Stands: MSS Type 44.
13. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp type by many manufacturers.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8 and or four-bolt riser clamps for heavy loads, MSS Type 42. Provide with 1” thick (minimum) neoprene pad on floor with 1/4” thick steel plate to distribute riser clamp weight to pad.
   1. Pre-insulated two-bolt riser clamps up to 4” diameter. Manufacturer: Hydra-Zorb #Klo-Shure Titan Riser Clamp or equal.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
   1. Steel Turnbuckles: MSS Type 13.
   2. Steel Clevises: MSS Type 14.
   3. Swivel Turnbuckles: MSS Type 15.
   5. Steel Weldless Eye Nuts: MSS Type 17.

F. Building Attachments: Except as otherwise indicated by the Structural Engineering design, provide factory-fabricated building attachments of one of the following types listed.
   1. Concrete Inserts:
      a. MSS Type 18.
      b. Manufacturers: Hilti #KCS-MD (for metal deck) or HCI-WF (for wood forms), Simpson Strong Tie #Blue Banger Hanger, Powers Fasteners #Bang-It (for metal deck) or #Wood-Knocker (for wood forms), or equal.
   2. Steel Brackets: One of the following for indicated loading:
      b. Medium Duty: MSS Type 32.
      c. Heavy Duty: MSS Type 33.
   3. Horizontal Travelers: MSS Type 58.
   4. Concrete Screw Anchors: For floor mounted attachments with maximum allowable pullout and shear force of 250 lbs. (1.1 kN) per anchor regardless of size.
      a. Manufacturers: Hilti #Kwik Hus EZ-1, Simpson Strong-Tie #Titen HD (or Rod Hanger version), Powers Fasteners #Wedge-Bolt+ (Screw Anchor), Powers Fasteners #Vertigo+ (Rod Hanger), Powers Fasteners #Snake+ (Internally Threaded Screw Anchor), or equal.
   5. Torque-Controlled Expansion Anchor:
      a. Manufacturers: Hilti #Kwik Bolt TZ, Simpson Strong Tie #Strong-Bolt 2, Powers Fasteners #Power-Stud+ SD1 or Power-Stud+ SD2, or equal.
   6. Screws and Bolts:

7. Eye Bolts:

8. Powder-Driven Concrete Anchors:
   a. Only for existing concrete structures with minimum 4000 psi concrete compressive strength.
   b. Minimum embedment of 1” (25 mm).
   c. Maximum allowable load of 50 lbs (0.2 kN) per anchor.
   d. Manufacturer: Hilti #X or D Series, Powers Fasteners #CSI Series, or equal.

G. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.
   1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
   2. Insulation Protection Shields: MSS Type 40, 18” minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
   3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert. Alternately Polyisocyanurate Urethane with a minimum flexural strength of 60 psi, fully encased in 360 PVC (1.524 mm thick) SNAPITZ. Provide assembly of same thickness as adjoining insulation.
   4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain tubing and join insulation at clevis hangers and strut-mounted clamps. Manufacturers: Klo-Shure Insulation Coupling or equal.

H. Miscellaneous Materials:
   1. Metal Framing: Provide products complying with NEMA STD ML1.
   2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
   3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand by volume, with minimum amount of water required for placement and hydration.
   4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards. Manufacturer: B-Line or equal.
   5. Copper Pipe Brackets: Copper plated brackets. Insulate brackets attached to metal studs with felt. Manufacturer: HOLDRITE, Sioux Chief or equal.

2.3 SEISMIC RESTRAINT/VIBRATION ISOLATION REQUIREMENTS

A. Equipment, piping, and all system appurtenances (including weight of normal operating contents) shall be adequately restrained to resist seismic forces. Restraint devices shall be designed and selected to meet seismic requirements as defined in the latest code editions with State Amendments, applicable local codes, and applicable Importance Factors and Soil Factors. Refer to Section 220548 Vibration Isolation for Plumbing Equipment or Section 220549 Seismic Restraint for Plumbing Piping and Equipment, as applicable.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-penetration and membrane penetration of fire-resistance-rated assemblies shall be caulked, sealed and/or insulated as required to maintain the fire (F) rating and temperature rise (T) rating of the penetrated assembly. Install per manufacturer’s installation instructions.
and conform with ASTM E814 or UL 1479 and comply with Chapter 7 of the Building Code. Refer to drawings for additional requirements.

B. Through-penetrations of rated floor assemblies by floor sinks, trench drains, and similar deep plumbing fixtures, shall be protected by a firestop system with an F rating and T rating of not less than one hour but not less than the required rating of the floor penetrated. Manufacturer: 3M #System F-A-1131 or F-A-1160, Hilti #System F-A-1135 or F-A-1137, or equal systems as tested for specific installation.

C. Through-penetrations of rated floor assemblies by floor drains, tub drains or shower drains contained and located within the concealed space of a horizontal assemblies do not require compliance to a T rating.

D. Manufacturers: 3M, Hilti, Metacaulk, STI Firestop, ProSet or equal.

2.5 ACCESS PANELS AND ACCESS DOORS

A. Provide all access doors and panels to serve equipment under this work, including those which must be installed, in finished architectural surfaces. Frame of 16-gauge steel, door of 20-gauge steel. 1” flange width, continuous piano hinge, key operated, prime coated. Refer to Architectural Specifications for the required product Specification for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels is not shown on Plans. Access doors shall be of a size to permit removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer or concealed valve. Use no panel smaller than 12” x 12” for simple manual access, or smaller than 24” x 24” where personnel must pass through. Provide cylinder lock for access door serving mixing or critical valves in public areas.

B. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to serve equipment under this work and in the proper sequence to keep in tune with construction and with prior approval of the Owner’s Representative. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.

C. Acceptable Manufacturers: Milcor, Karp, Nystrom, or Elmdor/Stoneman.

D. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

2.6 PIPING

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties

2.7 VALVES

A. Refer to Section 221000 Plumbing Piping, Valves and Specialties.

2.8 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 22 Sections. Where more than single type is specified for application, selection is installer’s option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.
B. Plastic Pipe Markers:
1. Pre-tensioned Pipe Labels: Precoiled, semi-rigid plastic formed to partially or fully cover the circumference of pipe, or insulated pipe, and to attach to pipe without fasteners or adhesive complying with ANSI A13.1. Minimum letter size shall be 1/2” high.
2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape. Minimum letter size shall be 1/2” high.
3. Insulation: Furnish 1” thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2” beyond each end of plastic pipe marker.
4. Arrows: Point each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
5. Pipe Label Color Schedule:
   a. Compressed Air piping:
      1) Background Color: Blue.
   b. Other piping services:
      1) Background Color: Comply with ANSI and ASME A13.1 standards.

C. Valve Tags:
1. Brass Valve Tags: Provide 1-1/2” diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4” high letters and sequenced valve numbers 1/2” high, and with 5/32” hole for fastener. Fill tag engraving with black enamel.
2. Plastic Laminate Valve Tags (indoors only): Provide 3/32” thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4” high letters and sequenced valve number 1/2” high, and with 5/32” hole for fasteners.
3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves and manufactured specifically for that purpose.

D. Access Panel Markers: Provide 1/16” thick engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve.

E. Plastic Equipment Signs:
1. Provide 3” x 5” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2” high.
2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
   a. Name and plan number.
   b. Equipment service.
   c. Design capacity.
   d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.
4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2”x11” bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

F. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Inc., Brimar or equal.
PART 3 EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal or otherwise irregular work, unless so indicated on Drawings or approved by Owner's Representative.

C. Install all items specified in this section of the Specification under the full purview of local and state governing agencies.

3.2 PERFORMANCE OF WORK

A. Examine areas, physical conditions and phasing requirements under which materials are to be installed. Layout the system to suit the different types of construction and equipment as indicated on the drawings.

B. Work shall start immediately after authorization has been given to proceed so that the overall progress of the construction is not delayed. No foundry items to be installed until submittals have been approved.

C. Coordinate with other trades as necessary to properly interface components of the plumbing system.

D. Follow manufacturer’s directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the drawings or covered in these Specifications.

E. The omission from the drawings or Specifications of any details of construction, installation, materials, or essential specialties shall not relieve the Contractor from furnishing the same in place for a complete system.

3.3 MANUFACTURER’S DIRECTIONS

A. Follow manufacturers’ directions and recommendations in all cases where the manufacturers of articles provided on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

3.4 INSTALLATION

A. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision, coordination or failure to make proper and timely provisions, the alterations shall be made to the satisfaction of the Owner’s Representative and at the Contractor’s cost.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defective materials.

3.5 SUPPORTS AND HANGERS
A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with all trades and testing agency representatives to coordinate work associated with placement of such work.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where gypcrete is indicated, install reinforcing bars through opening at top of inserts.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, supports, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire, stranded wire, or perforated metal to support piping, and do not support piping from other piping.

E. Install a minimum of one hanger within 12" of each change of direction (only one required on either side of elbow), at the end of a pipe run or concentrated load, and within 36" of every piece of equipment. Hangers shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one hanger is required.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

G. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

H. Horizontal Hanger Spacing in accordance with following minimum schedules (other spacings and rod sizes may be used in accordance with MSS SP-58 and the SMACNA Seismic Restraint Manual using a safety factor). Comply with more restrictive requirements of local codes where those exceed the following minimum criteria.

1. Steel Pipe (Liquid Filled):

<table>
<thead>
<tr>
<th>STEEL PIPE SIZE (LIQUID FILLED)</th>
<th>HANGER/SUPPORT SPACING (MAXIMUM)</th>
<th>ROD SIZE (MINIMUM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1-1/4&quot;</td>
<td>5 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>1-1/2&quot; and 2&quot;</td>
<td>7 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>2-1/2&quot; and 3&quot;</td>
<td>10 feet</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>4&quot; to 12&quot;</td>
<td>10 feet</td>
<td>5/8&quot;</td>
</tr>
</tbody>
</table>

2. Steel Pipe (Gas Filled to meet or exceed NFPA-54):

<table>
<thead>
<tr>
<th>STEEL PIPE SIZE (GAS FILLED)</th>
<th>HANGER/SUPPORT SPACING (MAXIMUM)</th>
<th>ROD SIZE (MINIMUM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>4 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>3/4&quot; to 2&quot;</td>
<td>6 feet</td>
<td>3/8&quot;</td>
</tr>
</tbody>
</table>
3. Copper Pipe (Water Filled):

<table>
<thead>
<tr>
<th>COPPER PIPE SIZE</th>
<th>HANGER/SUPPORT SPACING (MAXIMUM)</th>
<th>ROD SIZE (MINIMUM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot;</td>
<td>6 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>3/4&quot; to 2&quot;</td>
<td>6 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>2-1/2&quot; to 4&quot;</td>
<td>8 feet</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>5&quot; to 8&quot;</td>
<td>10 feet</td>
<td>1/2&quot;</td>
</tr>
</tbody>
</table>

4. Provide a minimum of one hanger for each section of pipe. Where an excessive number of fittings are installed between hangers, provide additional reinforcing.

I. Vertical Support Spacing in accordance with following minimum schedules:

1. Steel Pipe (Water and Air Filled):
   - Pipe Size | Vertical Support Spacing (Maximum)
   - All sizes | Base and every other floor, not to exceed 25 feet

2. Steel Pipe (Gas Filled):
   - Pipe Size | Vertical Support Spacing (Maximum)
   - 1/2"      | 6 feet
   - 3/4" to 1"| 8 feet
   - 1-1/4" and larger | Every floor level

3. Copper Pipe:
   - Pipe Size | Vertical Support Spacing (Maximum)
   - All sizes | Base and each floor, not to exceed 10 feet

J. Sloping, Air Venting, and Draining:

1. Slope all compressed air branch piping down toward main risers at 1” per 100’.

K. Provisions for Movement:

1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units. Where hot water pipes are installed inside walls and ceilings do not firmly attach pipes to framing as necessary to avoid noise generation during expansion and contraction.

2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.

3. Insulated Piping: Comply with the following installation requirements:
   - a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation.
   - b. Shields: Where low compressive strength insulation or vapor barriers are indicated on cold water piping, install shields or inserts.
   - c. Saddles: Where insulation without vapor barrier is indicated install protection saddles.

L. Installation of Anchors:

1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.

2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.

3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer’s written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs, at intermediate points in pipe runs between expansion loops and bends.

M. Adjusting:
1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer’s touch-up paint.

3.6 WALL, FLOOR, AND ROOF PENETRATIONS

A. All pipe penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Penetrations of fire-resistance-rated assemblies shall be protected by an approved firestop system installed and tested in accordance with ASTM E119, ASTM E814, UL 263 or UL 1479. The system shall have an F rating/T rating of not less than therequired rating of the floor or wall penetrated. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below. Systems shall have an F rating of not less than 1 hour but not less than the required fire resistance rating of the assembly being penetrated. Systems protecting floor penetrations shall have a T rating of not less than 1 hour but not less than the required fire resistance rating of the floor being penetrated. Floor penetrations contained within the cavity of a wall at the location of the floor penetration do not require a T rating. No T rating shall be required for floor penetrations by piping that is not in direct contact with combustible material.
1. Uninsulated pipe penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each uninsulated pipe.
2. Insulated pipes penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each insulated pipe.
3. Uninsulated pipe penetrations through fire rated walls and floors, and through roof: penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each uninsulated pipe to provide minimum 1/4” annular space between the outside of the pipe surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
4. Insulated pipe penetrations through fire rated walls and floors, and through roof: pipe penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each insulated pipe to provide minimum 1/4” annular space between the outside of the insulation surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
5. Uninsulated pipe penetrations through foundation and basement walls: penetration sizes shall be larger than the outside diameter of each uninsulated pipe to allow adequate space for installation of mechanical link seals. Coordinate with specific manufacturer requirements.

3.7 PLUMBING FIXTURE THROUGH-PENETRATION AND MEMBRANE PROTECTION

A. Fire-resistance-rated assemblies shall be protected at membranes and/or through penetrations where plumbing fixtures are installed in accordance with ASTM E119, ASTM E814, UL 263 or UL 1479.
B. Floor penetrations by floor drains, tub drains or shower drains contained and located within the concealed space of a horizontal assembly do not require a T rating as allowed by Chapter 7 of the Building Code.

C. Floor penetrations by floor sinks, trench drains and other fixtures that penetrate through the assembly must be enclosed within a rated enclosure with a comparable F/T rating of the assembly. Coordinate construction of fixture enclosures with Architectural design and General Contractor as required to comply with Chapter 7 of the Building Code.

D. Plumbing fixtures that penetrate into rated membranes, without penetrating through the membrane, shall be protected to maintain the fire-resistance rating of the assembly as required by Chapter 7 of the Building Code. Coordinate installation of fixtures with Architectural design and General Contractor. Manufacturer: 3M #Interam Endothermic Mat or equal.

3.8 WALL AND PIPE SIZING COORDINATION

A. Pipes routed horizontally or vertically in framed wall enclosures shall be limited to sizes that fit within the available free area without impacting the construction of the wall or intent of architectural floor plans. Maximum piping diameters shall be adjusted as necessary to accommodate insulation, fittings and pipe crossings inside the wall enclosure. Sizing is based on the following criteria:

1. 4" Stud Wall: Maximum 2" outside diameter of pipe and/or fittings.
2. 6" Stud Wall: Maximum 4" outside diameter of pipe and/or fittings.
3. 8" Stud Wall: Maximum 6" outside diameter of pipe and/or fittings.
4. 10" Stud Wall: Maximum 8" outside diameter of pipe and/or fittings.
5. 12" Stud Wall: Maximum 10" outside diameter of pipe and/or fittings.

3.9 PIPING INSTALLATION

A. The word "piping" shall mean all pipes, fittings, nipples, valves and all accessories connected thereto.

B. Run piping generally parallel to the axis of the building, arranged to conform to the building requirements and to suit the necessities of clearance for other mechanical ducts flues, conduits and work of other trades and close to ceiling or other construction as practical, free of unnecessary traps or bends.

C. Ream or file each pipe to remove burrs. Inspect each length of pipe and each fitting for workmanship and clear passageway.

D. All piping shall be inspected for defects and flaws prior to installation. Remove any damaged piping from job site. Piping shall be thoroughly cleaned of dirt, debris or rust.

3.10 VIBRATION CONTROL ISOLATORS

A. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

B. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or
bearing points. Remove space blocks and similar devices intended for temporary support during installation.

C. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

D. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

E. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

F. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

3.11 PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Division 9: Painting. Painting schemes shall comply with ANSI A13.1. Paint all exposed materials such as piping, equipment, insulation, steel, etc. Exposed gas piping outside the building shall be painted.

B. All exposed work under Division 22 shall receive either a factory finish or a field prime coat finish, except:
   1. Exposed copper piping.
   2. Aluminum jacketed outdoor insulated piping.

3.12 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment. Identification is not required inside wall assemblies or under concrete slabs.

B. Piping System Identification:
   1. Install pipe markers on each system indicated to receive identification and include arrows to show normal direction of flow.
   2. Locate pipe markers as follows:
      a. Near each valve and control device.
      b. Near each branch, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
      c. Near locations where pipes pass through walls, floors, ceilings, or inaccessible enclosures.
      d. At access doors, manholes, and similar access points which permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.
      f. Spaced horizontally at maximum spacing of 50' along each piping run, with minimum of one in each room. Vertically spaced at each story traversed.
   3. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipe where flow is allowed in both directions.
   4. Provide pipe identification on:
      a. Compressed air piping.
b. Other piping systems.

C. Valve Tag Identification: Install tags on valves and control devices in piping systems, except at check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
   1. Provide valve tags for:
      a. Compressed air piping.
      b. Other piping systems.

3.13 CLEANING EQUIPMENT AND MATERIALS

A. In addition to the requirements of Section 220500, provide for the safety and good condition of all materials and equipment until final acceptance by the Owner’s Representative. Protect all materials and equipment from damage. Provide adequate and proper storage facilities during the progress of the work. Special care to be taken to provide protection for bearings, open connections, pipe coils, pumps, compressors, and similar equipment.

B. All piping, finished surfaces, and equipment to have all grease, adhesive labels, and foreign materials removed.

C. All piping to be drained and flushed to remove grease and foreign matter. Pressure regulating assemblies, traps, flush valves, and similar items shall be thoroughly cleaned. Remove and thoroughly clean and reinstall all liquid strainer screens after the system has been in operation for ten days.

D. When connections are to be made to existing systems, the Contractor is to do all cleaning and purging of the existing systems required to restore them to the condition existing prior to the start of work.

3.14 TESTING

A. Provide all tests specified herein, in other Division 22 Sections, and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner’s Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Owner’s Representative to witness all field tests and conduct all field inspections. The Contractor to give the Owner’s Representative ample notice of the dates and times scheduled for tests. Any deficiencies to be completely retested at no additional cost.

C. Inspection to continue during installation and testing. Perform a final inspection of the equipment prior to installation to determine conformity to the type, class, grade, size, capacity, and other characteristics specified herein or indicated. Correct or replace all rejected equipment prior to installation.

3.15 OPERATING TESTING AND CERTIFICATION - PLUMBING SYSTEMS

A. Upon completion and disinfection, and prior to acceptance of the installation, the Contractor shall subject the plumbing system to operating tests to demonstrate satisfactory, functional,
and operating efficiency. Such operating tests to include the following information in a report with conclusions as to the adequacy of the system.

1. Time, date, and duration of tests.
2. Read all indicating instruments at half-hour intervals unless otherwise directed. Supply four copies of the test report to the Owner’s Representative.

3.16 VIBRATION AND DYNAMIC BALANCING

A. Vibration tolerances shall be as specified by the "International Research and Development Corporation", Worthington, Ohio, measured by the displacement, peak to peak, as follows:
   1. Pump and Electric Motors: Below severity chart labeled "SLIGHTLY ROUGH", maximum vibration velocity of 0.157 in/sec, peak.
   2. Compressors: Same as pumps.

B. Correction shall be made to all equipment which exceeds vibration tolerances specified above. Final vibration levels shall be reported as described above.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to the following:
   1. Pipe and Fittings
      a. Compressed air
   2. Valves
      a. Compressed air valves
   3. Piping specialties
   4. Pipe escutcheons
   5. Strainers
   6. Drip pans
   7. Air vent
   8. Dielectric unions
   9. Unions
   10. Flanges
   11. Pipe sleeves
   12. Sleeve seals
   13. Valve boxes
   14. Pipe coating

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods, including:
   1. Hangers and supports.
   3. Identification.

B. Section 223000: Plumbing Equipment.

C. Division 21: Fire Suppression.

D. Division 09: Finishes/Painting.

1.4 FIRE PROTECTION VALVES:

A. Refer to Section 211000.

1.5 REFERENCE STANDARDS

A. Comply with requirements of latest standard or as required by local AHJ.

B. American National Standards Institute (ANSI)/American Welding Society (AWS):
   1. ANSI/AWS A5.8: Specification for Filler Metals for Brazing.
2. ANSI/AWS A5.31: Specification for Fluxes for Brazing and Braze Welding.

C. American National Standards Institute (ANSI)/American Water Works Association (AWWA):

D. American Society of Mechanical Engineers (ASME):
1. ASME B1.20.1: Pipe Threads, General Purpose.
2. ASME B16.18: Cast Copper Alloy Solder Joint Pressure Fittings.
4. ASME B16.23: Cast Copper Alloy, Solder-Joint, DWV Drainage Fittings.
5. ASME B16.24: Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150 and 300.
6. ASME B16.29: Wrought Copper, and Wrought Copper Alloy Solder-Joint Drainage Fittings, DWV.
7. ASME B16.26: Cast Copper Alloy Fittings for Flare Copper Tubes.

E. American Society for Testing and Materials (ASTM):
1. Mechanical Couplings: ASTM A 536, ductile iron, or ASTM A 47, malleable iron coupling housing fabricated to manufacturer's specifications.
2. ASTM B584: Cast Copper Alloy for Grooved-End Fittings.
3. ASTM B75: Seamless Copper Tube for Grooved-End Fittings.
6. Hard Copper Tube: (Drawn Temper):
   a. ASTM B75: UNS Number C12200, drawn temper, seamless copper tube, wall thickness as specified.
   b. ASTM B88: Types K, L, and M, drawn temper, seamless copper tube.
   c. ASTM B306: Type DWV, drawn temper, seamless copper tube.
   d. ASTM B819: Type K and L, drawn temper, seamless copper tube.
7. Soft Copper Tube: (Annealed Temper):
   a. ASTM B75: UNS Number C12200, annealed temper, seamless copper tube, wall thickness as specified.
   b. ASTM B88: Types K and L, annealed temper, seamless copper tube.
   c. ASTM B280: Type ACR, annealed temper, seamless copper tube.
8. ASTM B584: Copper Alloy Sand Castings for General Applications.
9. ASTM B813: Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube.

F. Factory Mutual (FM):
1. FM-1680: Standard to evaluate intended application for long-term connection to hubless cast iron soil pipe aboveground and underground. Class I for Industrial/Commercial and Residential to 15 psi working pressure.

G. National Fire Prevention Association (NFPA):

H. Joining Materials
1. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
   a. ASME B16.21, nonmetallic, flat, asbestos-free, full-face type for Class 150 and 300 cast copper alloy flanges. 1/8-inch maximum thickness, except where thickness or specific material is indicated.
2. Mechanical Coupling Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment.
   a. Gasket design shall be such that the entire coupling housing is isolated from the system contents to prevent galvanic action and inhibit galvanic corrosion.
3. Proprietary filler metals having compositions not conforming to the exact ANSI/AWS A5.8 classifications for BCuP and BAg Series filler metals shall be permitted when used according to the manufacturer's written instructions.
4. Soldering and Brazing Fluxes: Soldering and brazing fluxes shall not exceed 0.20 percent Lead (Pb) content for any work in potable water systems.
   a. Soldering Fluxes: ASTM B813, liquid or paste type.
   b. Brazing Fluxes: ANSI/AWS A5.31, Type FB3-A or FB3-C.
   c. The use of brazing flux is not necessary if the components being joined are wrought copper tube, wrought copper fittings and the filler metal being used is of the BCuP series.
   d. Solder flux should not exceed any VOC regulatory limitations at the time of installation. Flux is currently considered a low emitting material with no VOC regulations, but must be confirmed with prior to installation.
5. ASTM B32 Solder Filler Metal:
   a. Alloy Sn95 or Alloy Sn94: Tin (Sn) approximately 95%, and Silver (Ag) approximately 5%, having 0.10% maximum Lead (Pb) content.
   b. Alloy Sb5: Tin (Sn) 95%, and Antimony (Sb) 5%, having 0.20% maximum Lead (Pb) content.
   c. Alloy E: Tin (Sn) approximately 95%, and Copper (Cu) approximately 5%, having 0.10% maximum Lead (Pb) content.
6. ANSI/AWS A5.8 Brazing Filler Metals:
   a. BCuP Series: Copper-Phosphorus alloys. The following brazing filler metals shall be used. Brazing filler metals shall conform to the requirements of the individual piping systems.
      1) BCuP - 2: Copper (Cu) and Phosphorus (P) 7.0 - 7.5%.
      2) BCuP - 3: Copper (Cu), Phosphorus (P) 5.8 - 6.2%, and Silver (Ag) 4.8 - 5.2%.
      3) BCuP - 4: Copper (Cu), Phosphorus (P) 7.0 - 7.5%, and Silver (Ag) 5.8 - 6.2%.
4) **BCuP - 5:** Copper (Cu), Phosphorus (P) 4.8 - 5.2%, and Silver (Ag) 14.5 - 15.5%.

### 1.6 QUALITY ASSURANCE

**A. Manufacturers Qualifications:**
1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
2. Replacement parts shall be readily available and stocked in the USA.

**B. Codes and Standards:**
1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.
2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes.
3. Perform all tests required by governing authorities and as required under all Division 22 Sections. Provide written reports on all tests.
4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.
5. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

**C.** All materials (such as piping, insulation, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 or UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified elsewhere in the construction drawings. Contractor shall review all mechanical and architectural plans and be fully aware of all building design criteria prior to installation of any work. Any work installed that does not comply with applicable life/safety requirements of all codes and standards shall be replaced and/or repaired at no additional cost to the Owner.

**D. Welding Standards:**
1. **Welding Qualifications:**
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The Owner's Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.
2. **Welding Procedures:**
   b. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   c. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.”

**E. Pressure Piping Standards**
1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.
2. Comply with ASME B31.9 Building Services Piping standard for the following services:
   a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
   b. Fluid pressure less than 350 psig.
3. Comply with ASME B31.3 Process Piping standard for the following services:
   a. Conveying fluid above 250°F (121°C).
   b. Toxic or flammable fluids.

1.7 DEFINITIONS
   A. AHJ: Authority Having Jurisdiction
   B. CSA: Formerly known as the Canadian Standards Association (CSA). CSA Group is a member of ISO. CSA is accredited by US OSHA as a Nationally Recognized Testing Laboratory (NRTL).
   C. Line Pressure Regulator: A pressure regulator placed in a gas line between the service regulator and the appliance regulator.
   D. Lead Free: Materials containing not more than 0.2 percent lead when used with respect to solder and flux and not more than a weighted average of 0.25 percent when used with respect to the wetted surfaces of pipes and pipe fittings, plumbing fittings, and fixtures, providing a specified definition and formula for determining “weighted average”.
   E. NRTL: Nationally Recognized Testing Laboratory, including UL, CSA and/or ETL.

1.8 WORKING PRESSURES
   A. All fittings, valves, pipe, specialties equipment shall be rated for the working pressure subjected in the installed locations.
   B. Drawings indicate working pressure in each system. The rating of the equipment and material shall not be less than that of the system pressures.
   C. Low pressure gas service generally includes pressures ranging from 7” to 11” (less than 0.5 psi) to serve gas appliances downstream of pressure regulators.
   D. Medium pressure gas service generally includes pressures ranging from 0.5 psi to 5 psi to distribute gas downstream of utility provided service regulators.
   E. High pressure gas service generally includes pressures greater than 5 psi including utility distribution pressures and additional installation restrictions where installed within buildings.

1.9 SUBMITTALS
   A. Product Data: Submit manufacturer’s technical product data for all piping, valves and specialties indicating dimensions, valve CV, tolerances etc.
   B. Shop Drawings: Submit shop drawings indicating underground piping installation showing all fittings with inverts. Indicate all footings and grade beams.
      1. For siphonic roof drainage system. Include calculations, plans, elevations and details.
   C. Maintenance Data: Submit maintenance instructions on accordance with requirements of Division 01.
D. Delegated-Design Submittal for each vibration isolation and seismic-restraint device.
   1. Seismic restraint calculations must be provided for all connections to the structure.
   2. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   3. 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 that riser system was examined for excessive stress and that none exists.
   4. Provide flexible joints, supports and piping joints as required to accommodate movement across seismic expansion joints and vertical building drift between floors.

1.10 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

C. Provide the additional extended warranty requirements that apply to all plastic piping systems with all types of joints and fittings.
   1. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.
   2. Contractor and Manufacturer warrant that, for a period of twenty-five (25) years from the date of Substantial Completion, the tubing will conform to the requirements of the Contract Documents and will be free from defects.
   3. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.
   4. In addition to the Contractor’s and Manufacturer’s obligations set forth above and elsewhere, if, within two (2) years after the date of the Substantial Completion, any part of the system is found to be defective or not in accordance with the requirements of the Contract Documents, the Contractor or Manufacturer, or both, shall correct it at their own expense promptly after receipt of written notice from the Owner to do so.
   5. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.
   1. All pipe, pipe fittings and valves shall be manufactured in North America, or may be import products where manufacturers are specifically identified below. Alternatives may
be acceptable, but must be submitted and approved by the Owner’s Representative prior to bidding.

OR

2. Upon request, the Owner’s Representative shall be furnished certification by the manufacturer, stating samples representing each lot have been tested and inspected as indicated in governing ASTM specifications have been met. Certification shall be accompanied by test reports as prepared in accordance with relevant ASTM sections governing Test Methods and Inspection. Tension Tests reports shall include breaking load, machined diameter of the test bars, and calculated tensile strength. Certification shall include the legal name and address of the manufacturer.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturer's names used herein, unless specifically noted that substitutes are not allowed.

2.2 STANDARD PIPE AND FITTING

A. Compressed Air Piping (Aboveground):
   1. Copper:
      a. Seamless copper tube:
         1) ASTM B88 or B75, Type K or L, hard temper.
         2) Manufacturers: Mueller Streamline, Cerro Flow Products, or equal.
      b. Fittings-Soldered:
         1) ASME B16.22 wrought copper alloy.
         2) ASME B16.18 cast copper alloy.
         3) Manufacturers: Nibco or equal.
      c. Fittings-Brazed:
         1) ASME B16.50 wrought or copper alloy.
         2) Manufacturers: Nibco or equal.
      d. Joints-Soldered:
         1) ASTM B32 filler metals. Manufacturers: Canfield #Silverflo or #Watersafe, Lucas Milhaupt #Silvabrite 100, or equal.
         2) Water soluble, lead free flux. Manufacturers: Oatey #H-20-95, JW Harris #Bridgit, La-CO #FLUX-RITE 90, Rectorseal #Nokorode, LucasMilhaupt #Silvabrite 100 or #95/5, or equal.
      e. Joints-Brazed:
         1) ANSI/AWS A5.8 filler metals. Manufacturers: Canfield #Sil-Can 5 or #Sil-Can 15, LucasMilhaupt #Sil-Fos, or equal.
         2) Water soluble, lead free flux. Manufacturers: JW Harris #Safety-Silv, LucasMilhaupt #Handy Flux, or equal.
   2. Steel:
      a. Pipe: ASTM A53, Schedule 40 black steel or galvanized steel pipe.
      c. Joints: Threaded or flanged in accessible areas. Welded in concealed areas such as shafts and plenums.

2.3 PIPE COATINGS AND WRAPPING

A. Pipe coatings and/or wrapping may be required for certain pipe materials where pipes are buried in corrosive soils or located in corrosive air environments. Verify local soil and air conditions with building department and engineered soils report, when available. Protect all underground buried steel and copper pipe and fittings. Protect all aboveground exposed steel
and copper pipe and fittings located in corrosive air environments. Buried cast iron does not require protection unless specifically required by the AHJ or project engineered Soils Report.

B. Furnish corrugated stainless steel tubing (CSST) with factory-applied corrosion–resistant polyethylene jacket for use in corrosive atmosphere. Coating properties include the following:
1. Gastite corrugated stainless steel tube jacket shall be UV-Resistant polyethylene meeting the requirements of ASTM E84 for flame spread and smoke density.

2.4 VALVES: GENERAL

A. General: Valve ratings shall exceed respective system operating pressures by 50% (minimum). All valves shall be line size unless otherwise noted. Use ball valves, butterfly valves or angle stop valves for manual shut-off. Gate valves may be used in backflow preventer assemblies.

B. Product Data: Submit manufacturer’s technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of valve. Submit valve schedule showing manufacturer’s figure number, size, location, and valve features for each required valve.

C. Shop Drawings: Submit manufacturer’s assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

D. Acceptable manufacturers (manufacturer and model number listed for individual valves indicates minimum acceptable by all manufacturers):
2. Check: Apollo, Hammond, Nibco (commercial grade, US manufacturer only), Milwaukee, Victaulic, Watts or equal.
3. Lubricated Plug Valves: Homestead, Resun, Rockwell, or equal.

E. Valve Identification: Provide valves with manufacturer’s name (or trademark) and pressure rating clearly marked on the valve body.

F. Operators: Provide handwheels, fastened to valve stem, for valves other than quarter-turn. Provide lever handle for quarter-turn valves, other than plug valves. Provide one wrench for every 10 plug valves, and one in each size. Provide extended levers/stems for valves on insulated lines. For manual valves 2-1/2” and larger located 8 feet above the floor in mechanical rooms provide chain operator to permit operating the valve from 4’-0” above floor.

G. Valve Features:
1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features. Comply with ASME B31.9 for building services piping, and ASME B31.1 for power piping.
3. Drain: Comply with MSS SP-45 and provide threaded pipe plugs.
7. Flangeless: Valve bodies manufactured to fit between flanges complying with ASME B16.1 (cast iron), ASME B16.5 (steel), or ASME B16.24 (bronze).

2.5 COMPRESSED GAS AND VACUUM SERVICE VALVES

A. Ball Valves:
   1. 4" and Smaller: 175 psi working pressure, 3-piece bronze body, threaded ends or sol, stainless steel ball, stainless steel stem, steel handle with memory stop tab, full port. Apollo #82 Series or equal.

B. Butterfly Valves:
   1. 2-1/2" and Larger: MSS SP-67, lug wafer ductile iron body, stainless steel disc, stainless steel stem, EPDM seat, memory stop control, lever handle. Mount stem in horizontal position. Apollo #LD141/WD141 Series or equal.

C. Air Vent Needle Valves:
   1. 3/4" and Smaller: 200 psi working pressure, needle globe valve, bronze body, threaded ends, bronze stem, steel wheel handle. Milwaukee #600 or equal.

D. Quick Couplings:
   1. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.
   2. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and brass, stainless-steel or nickel-plated-steel operating parts.
      a. Socket End: With one-way push-to-connect valve and threaded inlet for connection to piping or threaded hose fitting.
      b. 1/4" coupler size, 30 cfm design flow rate, 190 psi pressure rating.

E. Aluminum Dome Manifold:
   1. 3-port domed aluminum air line manifold connected downstream of shutoff valve, 3/8" inlet thread and three 1/4" outlet threads for three quick couplers, rated for 300 psi working pressure.

2.6 PRESSURE REDUCING VALVES

A. Pressure Reducing Valves (PRV) - Up to 2-1/2"
   1. Lead free single seated, direct operated type; high capacity, having bronze body, serviceable in line, sealed spring cage, reinforced Buna-N diaphragm, by-pass feature, pressure gauge tapings, inline strainer and complying with requirements of ASSE Standard 1003.
   2. Manufacturers: Watts #LF 223 Series, Apollo Lead Free #36HLF Series, Cash Acme, or equal. Refer to schedule on drawings as applicable.

B. Automatic Pressure Reducing Valves (ACV) - 1-1/2" and larger
   1. Lead-free pilot operated diaphragm valve type designed to automatically reduce a fluctuating higher upstream pressure to a constant lower downstream pressure. The valve shall contain a disc and diaphragm assembly that forms a sealed chamber below the valve cover, separating operating pressure from line pressure.
   2. The main valve body shall be ASTM A536 ductile iron. Internal cast components shall be ductile iron or 316 stainless steel. All ductile iron components shall be lined and coated with NSF 61 certified epoxy coating applied by electrostatic heat fusion. All main valve trim and throttling components shall be stainless steel. The diaphragm shall be constructed of nylon reinforced Buna-N.
3. Pilot control system for valves 3" and smaller shall contain a flow clean strainer, fixed orifice closing speed, adjustable opening speed control and pressure reducing pilot. Pilot control systems for valves 4" and larger shall contain an external Y-strainer, fixed orifice closing speed, pressure reducing pilot and isolation ball valves on all body connections. All pilot control systems shall utilize copper tubing and brass fittings. The adjustment range of the pressure reducing pilot shall be 30-300 psi.

4. Manufacturers: Watts #LFM115 Series, Apollo Lead Free #36HLF Series, Cash Acme, or equal. Refer to schedule on drawings as applicable.

2.7 PIPING SPECIALTIES

A. General:
1. Provide factory-fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service or provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is installer's option.

B. Pipe Escutcheons:
1. Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas. Prime zinc base paint finish is allowed for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide stainless steel, cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide stainless steel escutcheons, solid or split hinged.

C. Unions:
1. Unions shall be of type specified in following schedule:
   a. Black Steel, 2" and smaller: 250 lb. screwed malleable iron, ground joint, brass to iron seat.
   b. Black Steel, 2-1/2" and larger: 150 lb. cast iron screwed flanged, flat faced, full faced gasket.
   c. Soldered Copper or Brass Pipe, 2" and smaller: 150 lb. cast bronze or copper, ground joint, non-ferrous seat with soldered ends.
   d. Screwed Copper or Brass Pipe, 2" and smaller: 150 lb. cast brass, ground joint, brass to brass seat, with threaded ends.
   e. Flanged Copper or Brass Pipe, 2-1/2" and larger: two (2) 150 lb. cast bronze flanges.

D. Flanges:
1. Provide flanges at flanged connections to equipment, tanks and valves. Faces of flanges being connected shall be alike in all cases. Connection of raised-face flange to flat-faced flange not permitted.
2. Use ASTM A307, Grade B, bolts and nuts for cast iron flanges and ASTM A193 for steel flanges. Regular square head unfinished bolts with heavy semi-finished hex nuts ASTM A194. Cadmium plated where exposed to weather.
3. Ratings: 150 lb. or 300 lb. in high pressure portions.
4. **Type of pipe and corresponding flanges as follows:**
   a. **Screwed Black Steel Pipelines:** 125 lb. black cast iron screwed flange, flat faces.
   b. **Welded Steel Pipe:** 150 lb. black forges steel welding flanges, 1/16" raised face ASTM A181 Grade I. Use flat face when connected to flat faced companion flange.

**E. Dielectric Fittings:**
1. **Dielectric Unions:**
   a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate steel, galvanized steel, and zinc plated steel from non-ferrous piping to prevent galvanic action and related corrosion.
   b. Manufacturers: Watts #LF3000 Series, Zurn #DUX Series, or equal.

2. **Dielectric Waterways/Nipples:**
   a. Comply with standard IAPMO PS 66.
   b. Electroplated steel waterway/nipple complying with ASTM F1545 or ASTM F492.
   c. Pressure Rating: 300 psig (2070 kPa) at 225°F (107°C).
   d. End Connections: Male threaded or grooved.
   e. Lining: Inert and noncorrosive, propylene.
   f. Manufacturers: Mifab #MI-DE Series, Victaulic #Series 647, or equal.

3. **Dielectric Flanges:**
   a. Comply with standard ASSE 1079.
   b. Factory-fabricated, bolted, companion-flange assembly.
   c. Pressure Rating: 125 psig (860 kPa) minimum at 180°F (82°C).
   d. End Connections: Solder or brazed joint copper alloy and threaded ferrous; or threaded solder-joint copper alloy and threaded ferrous.
   e. Dielectric-Flange Insulating Kits:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Gasket: Neoprene or phenolic.
      3) Bolt Sleeves: Phenolic or polyethylene.
      4) Washers: Phenolic with steel backing washers.
   f. Manufacturers: Watts #LF3100 Series or equal.

**F. Transition Couplings:**
1. **Coupling connection for grooved end AWWA ductile iron pipe to grooved end IPS stainless steel pipe,** including valves or fittings of the same nominal size. Use grooved dielectric nipple for transition to copper tubing.
   a. **Housing:** Ductile iron conforming to ASTM A-536, grade 65-45-12 or ductile iron conforming to ASTM A-395, grade 65-45-15.
   b. **Coating:** Coal tar epoxy coating, 3 mils minimum thickness, for buried piping transition.
   c. **Gasket:** Grade “M” FlushSeal, halogenated butyl (brown color code). Temperature range –20°F to +200°F (−29°C to 93°C). Specially compounded to conform to ductile pipe surfaces. UL classified in accordance with ANSI/NSF 61 for cold potable water service.
   d. **Bolts/Nuts:** Heat-treated plated carbon steel or stainless steel 316 for buried applications, compliant with the physical and chemical requirements of ASTM A-449 and physical requirements of ASTM A-183.
   e. Manufacturers: Victaulic #Style 307 or equal.

**G. Pipe Sleeves:**
1. Provide fire proof sleeve assemblies utilizing UL rated sealant systems at all fire rated penetrations. For non-rated sleeve penetrations pack the annular space between the pipe and sleeve with fiberglass and/or mastic.
2. Sleeves shall provide a minimum 1/2" annular clearance around pipe. Where pipes cross through footings or footing walls provide a minimum 1” annular clearance between sleeve and pipe.

3. Sheet metal: Fabricate from 0.025” (0.64 mm) minimum, sheet metal; round tube closed with snap lock joint, welded spiral seams, or welded longitudinal joint.

4. Steel pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

5. Iron pipe: Fabricate from cast iron or ductile-iron pipe; remove burrs.

6. Plastic and copper pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.

7. Sleeves through interior concrete walls and floors: Telescopic, submerged, adjustable sleeves to extend a minimum of 1” above finished floor. Manufacturers: Adjust-to-Crete, Crete-Sleeve, Hilti, or equal.

8. Through exterior walls and floor on grade: 150-pound class cast-iron pipe sleeve. Where waterproof membranes are used, provide membrane clamps. For insulated piping, sleeve diameter shall not be less than diameter of insulated pipe.

9. Cast-in-place watertight device for protecting penetrating objects from expansion and contraction of concrete. Factory-assembled for use in cast-in-place concrete floors and walls and consisting of two outer sleeves and a one-piece radial extended-flange waterstop gasket, with mid-body seal for embedment and sealing to concrete slab and continuous water seal extending to the penetrating pipe.
   a. Outer Sleeves: EPDM attached to the mid-body seal forming an area with which to attach the device to the structural reinforcing rod determining the position of sleeve in the wall.
   b. Water Stop Mid-Body Seal: Flexible polymer seal with radial extended flange consisting of one to three concentric raised rings which lock into concrete, maintaining seal over time as concrete contracts from sleeve.
   c. Manufacturers: HoldRite #HydroFlame, or equal.

H. Mechanical Sleeve Seals-Aboveground Penetrations:

1. Aboveground: For sleeves passing through walls or floors provide a non-toxic 3-hour rated fire resistant silicone foam sealant with a Flame Spread Rating of 20. Sealant to be tested and approved under UL 263, ASTM E119, and NFPA 251 Standards. All fire rated penetrations shall be sealed with approved UL System.

2. Local Approvals: All seals to be provided shall be in accordance with the regulations of all governing agencies of the city, county, and State Fire Marshal's Office.

3. Wood Decking Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in concrete floors formed with wood decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, fire, and hot gasses.
   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/HOLDRITE, Hydroflame Sleeve, or equal.
   b. Consists of an outer sleeve lined with an intumescent strip, and a radial extended flange attached to one end of the sleeve for fastening to concrete formwork.
   c. Include a waterstop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab.
   d. Provide one-hour, two-hour and/or three-hour fire-resistance rated assemblies as required and tested according to ASTM E 814 or ANSI/UL 1479.

4. Steel Decking Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in floors formed with steel decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, hot gasses and fire.
   a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/Holdrite; Hydroflame CMD Metal Deck Device, or equal.
   b. Consists of an outer sleeve lined with an intumescent strip, and wide outside wings attached to one end of the sleeve for fastening to metal deck concrete formwork and span deck corrugations.
c. Includes a cone attached to the base for extending the device through the metal deck and a water stop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab.

d. Provide one-hour, two-hour and/or three-hour fire-resistance rated assemblies as required and tested per ASTM E 814 or ANSI/UL 1479.

5. Concrete Description: Cast-in-place, watertight tub box drain block out firestop device for use in floors formed with wood decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke and fire, and hot gasses.

a. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/Holdrite, Hydroflame Tub Box, or equal.

b. Consists of a reinforced polymer box containing a 2-1/2-inches (63.5 mm) thick polystyrene foam insert with an upper water seal consisting of absorbent material and a pitched water trough.

c. Include a sleeve lined with an intumescent strip, a radial extended flange attached to one end of the sleeve for fastening to concrete formwork.

d. Include two support legs each with a radial extended flange for balance and for fastening to concrete formwork, and a lower water-seal and radial extended flange attached to the lower end of the sleeve for fastening to concrete formwork and a water stop gasket with three concentric raised rings for embedment and sealing to the concrete slab.

e. Provide one-hour, two-hour and/or three-hour fire-resistance rated assemblies as required and tested per ASTM E 814 or ANSI/UL 1479.

I. Low Pressure Y-Type Pipeline Strainers:

1. Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125% of the working pressure of piping system, with Type 304 stainless steel screens, with 3/64" perforations (233 @ 0.045" perforations per square inch).

2. Threaded ends, 2" and smaller: Cast-iron body, screwed screen retainer with centered blowdown fitted with hose bibb. Manufacturers: Sarco, Wheatley, Mueller or equal.

3. Flanged ends, 2-1/2" and larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with hose bibb. Manufacturers: Sarco, Wheatley, Mueller or equal.

4. Grooved ends 2-1/2" and larger: Ductile iron body, bolted screen retainer with off center blowdown fitted with hose bibb. Manufacturers: Victaulic, Gustin-Bacon or equal.

J. Valve Boxes:

1. Concrete body, cast iron cover with vandal resistant screws, extensions as required to extend full depth to valve. Valve box cover lettering shall correspond to the valve service, "Water", "Gas", "Fire", "Sewer", etc.

2. Manufacturers: Christy #G8 or equal.

2.8 EXPANSION COMPENSATORS

A. General: Pipe expansion, in general, is to be absorbed in bends, swing joints, expansion loops, and offsets. All piping mains, branches and runouts shall be installed to allow for free expansion and contraction without developing leaks or undue stressing of pipe. Stresses shall be within allowable limits of ASME B31.1 for pressure piping. Vertical piping shall be provided with expansion joints at each floor. Expansion products to conform to the standards of the Expansion Joint Manufacturer's Association. Expansion joints shall not require packing. Installer shall select materials and pressure/temperature ratings to suit intended service. Select packless expansion joints to provide 150% absorption capacity of calculated maximum piping expansion between anchors. All connections shall have ends to match piping system application.
B. Expansion Compensators (Pipe Compression and Extension): Multiple stainless steel bellows and stainless steel liner with shroud and end fittings. Manufacturers: Keflex #311 series or equal.

C. Flexible Expansion Joint/Seismic Connector for Steel Pipe: Stainless steel hose and braid, 180° return, CSA approved, and end fittings. Manufacturers: Metraflex #Metraloop or equal.

D. Flexible Connection for Steel Pipe (Piping and Equipment Located Outside the Building): Stainless steel hose and braid, with threaded or flanged ends. Manufacturers: Metraflex #SST or equal.

E. Flexible Connection for Copper Pipe: Bronze hose and braid, copper tube ends. Manufacturers: Metraflex #BBS or equal.
   1. For non-critical pump connections. Furnish with fluorelastomer tube and cover to ASTM D2000 Grade 1HK710. The body shall be reinforced with rectangular body rings and six bias plies of fiberglass/Kevlar fabric rated 190#/26" vacuum at 250°F. Provide galvanized flat (not L shaped) back up rings and control rods to limit maximum axial extension. Manufacturers: Garlock #206 EZ-FLO or equal.
   2. Flexible Ball Pipe Joints: Provide flexible ball pipe joints where indicated for piping systems, with materials and pressure/temperature ratings selected by installer to suit intended service. Design joints for 360° rotation, and with minimum of 50° angular flexing movement for sizes 1/4" to 4". Provide two composition gaskets for each joint. Barco or approved equal.

F. Pipe Alignment Guides: Provide pipe alignment guides on both sides of expansion joints, and elsewhere as indicated on drawings. Guide shall be of carbon steel construction with split guiding cylinder and integral anchor base and internal four finger two-piece spider. Cylinder wall thickness shall be equal to schedule 40 wall thickness of pipe being guided. Spider shall be capable of clamping directly to pipe and moving only in an axial direction while inside cylinder. Anchoring directly to building substrate. Manufacturers: Metraflex #Style IV or equal.

G. Expansion Loops: Provide field fabricated pipe expansion loops as an alternate to mechanical expansion joints.

PART 3 EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install water piping and fixtures uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work, unless so indicated on Drawings or approved by Architect or Owner’s Representative.

C. Pipe showing rust or cracks in coating shall be removed and replaced.

D. Follow manufacturers’ directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.

E. Coordinate the work between the various Plumbing Sections and with the work specified under other Divisions of the work or contracts toward rapid completion of the entire project. If
any cooperative work must be altered due to lack of proper supervision or failure to make proper provisions in time, then the work hereunder shall include all expenses of such changes as are necessary in the work under other contracts, and such changes shall be directly supervised by and made to the satisfaction of the Owner’s Representative.

F. The cooperative work not included in the Plumbing Division related to the general construction work is as follows:
   1. All formed concrete work.
   2. Framed openings in masonry and other Architectural and Structural elements.
   3. Wood grounds and nailing strips in masonry and concrete.
   4. Sloping of floors to drains and floor sinks.
   5. Sloping of roof surfaces to roof drains and overflow drains.

G. Inspect all material, equipment, and apparatus upon delivery and do not install any that may be subject to rejection as a result of damage or other defects. Provide tarps (waterproof membrane) to protect equipment and piping delivered to and stored at the site.

H. Piping in connection with a plumbing system shall be so installed that piping or connections will not be subject to undue strains or stresses, and provisions shall be made for expansion, contraction, and structural settlement. No plumbing piping shall be directly installed or embedded in concrete or masonry. No structural member shall be seriously weakened or impaired by cutting or notching. Sleeves, sealants and/or gasketing shall be utilized where penetrating through concrete or masonry assemblies.

3.2 PIPES SIZES TO EQUIPMENT

A. General: Pipe sizes indicated shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of equipment.

B. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valve.

3.3 PIPING INSTALLATION

A. Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints or couplings, but with adequate and accessible unions for disassembly and maintenance or replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16” misalignment tolerance. Comply with ASME B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and column lines. Locate runs as shown or described by diagrams, details, and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2” where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1” clearance outside insulation. Whenever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as indicated.
C. A blue insulated copper tracer wire or other approved conductor shall be installed adjacent to underground nonmetallic piping. Access shall be provided to the tracer wire or the tracer wire shall terminate above ground at each end of the nonmetallic piping. The tracer wire size shall be not less than 14 AWG and the insulation type shall be suitable for direct burial.

3.4 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. Pipes passing through foundation walls or grade beams shall be provided with a relieving arch or a pipe sleeve built into the foundation wall or grade beam. The sleeve shall be a minimum of two (2) pipe sizes larger than the pipe passing through the wall or beam. Coordinate specific sleeve penetration locations with structural design for placement of sleeves.

C. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) minimum annular clear space between piping and concrete slabs and walls.
   1. When cast-in-place watertight sleeve seals are required, select sleeve size to match the size and type of pipe to be installed.
   2. Sleeves are not required for core-drilled holes.

D. Install sleeves in concrete floors, concrete roof slabs, and concrete/masonry walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2” (50 mm) minimum above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

E. Install sleeves for pipes passing through fire rated interior partitions as required by assembly construction.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4” (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section “Joint Sealants.”
   4. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section “Penetration Firestopping.” Exception: When fire-resistance-rated cast-in-place watertight sleeve seals are required for floor penetrations, additional firestopping is not necessary.

3.5 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.
3.6 PIPING SYSTEM JOINTS

A. All piping shall be cut squarely, free of rough edges/burrs, and reamed to full bore. Piping shall be mechanically cleaned prior to make-up of joints and fully inserted into fittings. Bevel plain ends of steel pipe.

B. Piping shall be capped during construction to prevent entry of foreign material.

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

D. Provide joints of type indicated in each piping system and as required to meet the maximum allowable working pressure and maximum testing pressures.

E. Thread pipe in accordance with ANSI/ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Remove excess cutting oil from piping prior to assembly.

1. Apply appropriate (Teflon) tape or thread compound to external pipe threads. on male threads at each joint and tighten joint to leave not more than three (3) threads exposed.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

F. Soldered and brazed copper water tube and fittings: Comply with maximum allowable rated internal working pressures as defined in ASME B31.9, and matching table in ASHRAE Handbook-HVAC Systems and Equipment, based on maximum service temperature and pipe diameter. Soldered and brazed joints shall only be installed where complete access is available on all sides of the pipe to assure that visual inspection can occur for 360° circumference. Blind soldering or brazing is not allowed, in such cases the use of mechanical type fittings shall be utilized. This would apply to situations such as pipes attach tight to floor or ceiling/roof requiring mechanical type joints.
## ASME B31.9-2008 Table 917.3
Rated Internal Working Pressure of Joints Made With Copper Water Tube and Solder Joint Fittings (psig)

<table>
<thead>
<tr>
<th>Solder or Brazing</th>
<th>Maximum Service Temperature (°F)</th>
<th>Types K, L, M Copper Water Tube in Nominal Sizes (inches)</th>
<th>Liquids and Gases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/4” to 1”</td>
<td>1-1/4” to 2”</td>
<td>2-1/2” to 4”</td>
</tr>
<tr>
<td>Tin Alloys</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM B32</td>
<td>100</td>
<td>500</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>400</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>200</td>
<td>175</td>
</tr>
<tr>
<td>Brazing Alloys</td>
<td>200</td>
<td>Tube Rating</td>
<td>Tube Rating</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>300</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td>270</td>
<td>190</td>
</tr>
</tbody>
</table>

G. Solder copper tube and fitting joints with lead free nickel/silver bearing solder meeting ASTM B-32, in accordance with plumbing code requirements, ASTM B828 and Copper Development Association (CDA) recommended procedures. Joints shall be cleaned by other than chemical means prior to assembly. "Shock" cooling is prohibited. Fluxes shall be applied liberally to the outside of the pipe and the solder cup of the fitting. Fluxes shall be water soluble for copper and brass potable water applications and shall meet CDA standard test method 1.0 and ASTM B813. Solder shall be applied until a full fillet is present around the joint. Solder and flux shall not be applied in such excessive quantities as to run down interior of pipe. Lead solder or corrosive flux shall not be present at the jobsite.

H. Mechanically Formed Extruded Tee Fittings: Form tee in copper tube according to ASTM F2014. Forming procedures shall be in accordance with the tool manufacturer’s recommendations. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar. Formed tee fitting shall not be greater than 50% of the diameter of the main run tube/pipe. Soldered joints are not allowed.
1. Mechanically formed extruded outlets shall be perpendicular to the axis of the run tube (main pipe). Holes shall be formed by drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the branch wall.
2. Branch tubes shall not restrict the flow in the run tube. A dimple (depth stop) shall be formed in the branch tube to ensure that penetration into the collar is of the correct depth. For inspection purposes, a second dimple shall be placed 0.25 inch above the first dimple. Dimples shall be aligned with the tube run.
3. Manufacturers: T-Drill or equal.

I. Braze copper tube and fitting socket or mechanically formed tee fittings with BCUP series filler metal without flux. Listed brazing flux shall be used for joining of copper tube to brass or bronze fittings and shall meet AWS FB3A or FB3C. "Shock" cooling is prohibited. A continuous fillet shall be visible around the completed joint. After cooling, flux residue shall be thoroughly removed with warm water and a brush prior to testing. Do not use BCUP filler on copper alloys containing over 10% nickel.
1. Brazing fittings may use a mechanically limited depth that is not less than the minimum cup depth (overlap) specified by ANSI/ASME B16.50 for Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings. Manufacturer of mechanical dimpler: Brazing Dimpler Corp or equal.
J. Depth of solder joint and braze joint fitting:

<table>
<thead>
<tr>
<th>Pipe Size (inches)</th>
<th>ASME 16.22 Solder Joint Socket Depth (inches)</th>
<th>ASME B16.50 Brazed Joint Socket Depth (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.50</td>
<td>0.22</td>
</tr>
<tr>
<td>3/4</td>
<td>0.62</td>
<td>0.25</td>
</tr>
<tr>
<td>1</td>
<td>0.75</td>
<td>0.28</td>
</tr>
<tr>
<td>1-1/4</td>
<td>0.97</td>
<td>0.31</td>
</tr>
<tr>
<td>1-1/2</td>
<td>1.09</td>
<td>0.34</td>
</tr>
<tr>
<td>2</td>
<td>1.34</td>
<td>0.40</td>
</tr>
<tr>
<td>2-1/2</td>
<td>1.47</td>
<td>0.47</td>
</tr>
<tr>
<td>3</td>
<td>1.66</td>
<td>0.53</td>
</tr>
<tr>
<td>4</td>
<td>2.16</td>
<td>0.64</td>
</tr>
<tr>
<td>5</td>
<td>2.66</td>
<td>0.73</td>
</tr>
<tr>
<td>6</td>
<td>3.09</td>
<td>0.83</td>
</tr>
<tr>
<td>8</td>
<td>4.09</td>
<td>1.28</td>
</tr>
</tbody>
</table>

K. Alternative domestic water piping mechanical press type connections with pre-approval from Owner's Representative. Copper press fittings shall be made in accordance with the manufacturer’s installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. The joints shall be pressed using the tool approved by the manufacturer. Copper press fittings shall conform to the material and sizing requirements of ASME B16.22. O-rings for copper press fittings shall be EPDM.

L. Cast-Iron Sanitary Sewer Joints: Comply with coupling manufacturer's Cast Iron Soil Pipe Institute Standards and installation instructions.

M. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

N. Joint Construction for Grooved-End, Ductile-Iron Water Piping to Copper Tubing: For transition site piping to building copper piping make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.

O. 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. Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

P. Weld pipe joints in accordance with recommendations of American Welding Society AWS D1.1 and ASME Boiler and Pressure Vessel Code Section IX.

1. Weld pipe joints only when ambient temperature is above 0°F.
2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
3. Use pipe clamps or tack-weld joints with 1" long welds, 4 welds for pipe sizes to 10", 8 welds for pipe sizes 12" and larger.
4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and at edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
5. Do not weld out piping system imperfections by tack-welding procedures. Refabricate to comply with requirements.
6. At Installer's option, install forged branch-connection fittings whenever branch pipe is indicated, or install regular T-fitting.

3.7 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping Outside of Building Footprint:
   1. Fittings for NPS 1-1/2" (DN 40) and Smaller: Fitting-type coupling.
   2. Fittings for NPS 2" (DN 50) and Larger: Sleeve-type coupling or grooved type fitting.

C. Transition Fittings in Aboveground Domestic Water Piping: Unions, flanges, grooved fittings, or connect to isolation valve to meet field conditions and maintain pressure testing requirements.

3.8 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing such as copper to zinc plated equipment fittings or copper to galvanized steel or black steel equipment.
   1. Dielectric Fittings for NPS 2" (DN 50) and Smaller: Use dielectric couplings, nipples, unions.
   2. Dielectric Fittings for NPS 2-1/2" to NPS 4" (DN 65 to DN 100): Use dielectric flange kits or threaded nipples.
   3. Dielectric Fittings for NPS 5" (DN 125) and Larger: Use dielectric flange kits.

B. Dielectric couplings are not required in the following locations:
   1. Unions in a copper piping system with connections to brass/bronze valves and devices.
   2. Unions in a copper piping system with connections to stainless steel valves and devices.
   3. Connections to water hammer arrestors.

3.9 VALVES

A. General: Except as otherwise indicated, comply with the following requirements:
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping. Locate valves to be accessible. Provided separate support as necessary.
   2. Install manual shutoff valves to isolate cold and hot water services to each restroom group. Back-to-back or adjacent men’s and women’s restrooms are considered a group. Shutoff valves shall be located immediately above or adjacent to the restroom(s) for easy maintenance access.
   3. Install valves on all services connected to kitchen equipment.
   4. Install valves, except butterfly valves, with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane without prior
written approval. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.

5. Install butterfly valves with stems mounted horizontally.

6. All valves mounted higher than 7’ above floor in mechanical rooms and where indicated shall be installed with stem horizontal and equipped with chain wheels and chains extending to 6’ above floor.

7. For multistory buildings with showers and without domestic cold water pressure booster system: Provide a pressure reducing valve in the cold water service downstream of the cold water branch serving the water heating equipment where the cold water service pressure is greater than 10 psi above the domestic hot water serving the remote shower mixing valves. This will equalize the pressures serving the shower valves to normalize the operation of the valves to assure proper temperature operation. The requirement for a pressure reducing valve cannot be assessed until completion of piping, valves, mixing valves and water heating installation.

8. Provide seismic shut off valve on the fuel gas main downstream of meter adjacent to outside of building, mounted per manufacturer instructions, level in all planes, and anchored to the building structure wherever possible to avoid nuisance tripping.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends of types of pipe/tube connections:
   1. Copper Pipe, 2-1/2” and Smaller: Soldered-joint valves.
   2. Steel Pipe, 2” and Smaller: Threaded joint valves.
   3. Larger Pipe Sizes: One of the following, at installer’s option:
      a. Flanged valves.
      b. Lug valves.

D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

F. Fluid Control: Except as otherwise indicated, install gate, ball, plug, circuit setter, globe, and butterfly valves to comply with ASME B31.9.

G. Swing Check Valves: Install in horizontal position with hinge pin horizontally perpendicular to center line of pipe. Install for proper direction of flow.

H. Wafer Check: Install between 2 flanges in horizontal or vertical position.

I. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

J. Backwater Valve: Provide backwater sewer valve in gravity discharge piping to protect the ground floor, and lower levels of the sanitary sewer system, where any floor levels are below the next upstream street manhole cover, not invert limited. Fixtures, including grease traps, installed on a floor level that is lower than the next upstream manhole cover of the public or private sewer shall be protected from backflow of sewage by installing an approved type of backwater valve. Fixtures on such floor level that are not below the next upstream manhole
cover shall not be required to be protected by a backwater valve. Fixtures on floor levels above such elevation shall not discharge through the backwater valve. Cleanouts for drains that pass through a backwater valve shall be clearly identified with a permanent label as “backwater valve downstream”.

K. Valve Identification: Tag each valve in accordance with Section 220500.

L. Cleaning: Clean factory-finished surfaces. Repair marred or scratched surfaces with manufacturer's touch-up paint.

3.10 TEMPERATURE GAUGES AND THERMOMETERS

A. General: Install temperature gauges/thermometers in vertical upright position and tilted to be easily read by observer standing on floor without supplemental illumination.

B. Install in the following locations and elsewhere as indicated:
   1. At outlet of hot water heaters/boilers over 100,000 Btuh (30 kW) input.

3.11 MECHANICAL SLEEVE SEALS

A. Loosely assemble rubber links around pipe with bolts and pressure plates located under each bolt head and nut. Push into sleeve and center. Tighten bolts until links have expanded to form a watertight seal.

B. Fire Barrier Penetration Seals: Fill entire opening with sealing compound in compliance approved and listed UL system number. Adhere to manufacturer's installation instructions.

3.12 SUPPORTS AND HANGERS

A. Refer to Section 220500 – Basic Plumbing Materials and Methods.

3.13 VIBRATION CONTROL ISOLATORS

A. Refer to Section 220548 – Vibration Isolation for Plumbing Piping and Equipment.

3.14 EQUIPMENT RAILS AND PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed.

C. Verify roof insulation thickness and adjust raise of cant to match.

3.15 EXPANSION COMPENSATION

A. Expansion Loops/Connectors at Expansion Joints:
   1. Provide flexible hose expansion loop(s) or connectors as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction, building settlement, or seismic movement of the piping system.
   2. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal hose, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.
   3. Flexible loops shall be capable of movement in the ±X, ±Y, and ±Z planes to meet or exceed the limits identified in the structural design.
4. Flexible hose expansion loops and connectors shall impart no thrust loads to system support, anchors or building structure.

5. Provide pipe anchors and pipe alignment guides as indicated, and elsewhere as determined by installer to properly anchor piping in relationship to expansion loops.

6. Where plans do not indicate spacing of guides or other pertinent information, install per manufacturer's recommendations.

B. Expansion Compensation for Risers and Terminals:
   1. Install connection between horizontal piping mains and vertical piping risers with at least five pipe fittings including tee in main. Install connections between piping risers and terminal units with at least four pipe fittings including tee in riser.

C. Thermal Expansion Compensation:
   1. Provide piping U-Bend, Z-Bend, L-Bend or flexible devices to accommodate thermal expansion and contraction in piping system where shown on drawings and as required to impart minimal stress in water piping and building structure.

3.16 EXCAVATION AND BACKFILL

A. Underground piping shall be installed in stable, open trench work. Trench excavations shall be a minimum of 16" wide, true to line and grade. Contractor shall exercise all due shoring and safety procedures. No stones larger than 1” may be present in the trench to a minimum depth of 4” below the trench bottom. The trench shall be free of job site debris, and free of corrosive media.

B. Pipe crown, outside the building footprint, shall be not less than 24” below the finished ground surface for metallic pipe, and 30” for non-metallic pipe, unless otherwise indicated on the Civil drawings or directed by the Owner’s Representative. Trenches shall be kept free of excess moisture and shall be kept open for only a short a time as necessary for installation, testing and inspection. Dispose of surplus excavation and seepage water as directed by the Owner’s Representative. Comply with minimum depths as defined in local plumbing code for building sewer piping outside the building footprint.

C. Piping shall be properly bedded and backfilled over stable trench bottom to a level of at least 12” above the pipe crown where located outside the building footprint, and not less than 2” above pipe crown where pipes are located within the building footprint. Use thin layers of unwashed sand, dampened but not puddle, and free of organic or corrosive materials and excessive moisture. Backfill shall be placed in thin layers not to exceed 6” and tamped by mechanical tampers to a minimum 90% Modified Proctor Density, in accordance with ASTM D-1557-58T. Alternate backfill material may be Class I or II SE-30+ fill with minimum 30 percent sand and maximum 1/2” diameter particle size.

D. Trenches shall be backfilled to a minimum depth of 36” prior where vehicle loading is required.

E. Replace to their original condition all turf, plants, concrete, asphalt, or other improvements which constitute landscaping, traffic areas or other improved areas which become disturbed by excavation. In graded and undeveloped areas, in addition to procedures specified above, backfill trenches with crown 8” above the surrounding surface.

F. Excavated and backfill in soils of unstable nature shall be provided as directed the Owner’s Representative.
3.17 PIPE INSPECTIONS

A. Inspections shall be performed at each phase while under tests required for administrative authorities, and prior to concealment, i.e. “rough-in”, “top-out” and “final”.

B. Inspection – Underground: All piping installed underground shall be inspected prior to burial by the Owner’s Representative. Contractor must notify Owner’s Representative no less than 24 working hours prior to inspection time. Should the piping be buried prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

C. Inspection – Aboveground: All piping installed Aboveground shall be made available for inspection upon completion and prior to finish of walls and ceilings. Contractor must notify Owner’s Representative no less than 24 working hours prior to the desired inspection time. Should the piping be hidden within the structure prior to inspection the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

3.18 CLEANING, FLUSHING, DISINFECTING

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any).

B. Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports, and accessory items.

C. Inspect pressure piping in accordance with procedures of ASME B31.

D. Disinfect water mains and water service piping in accordance with Section 220500.

3.19 TESTING

A. Provide all tests specified hereinafter. All tests shall meet or exceed the minimum requirements of applicable codes and local ordinances. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Architect, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.

B. Piping: Remove from the system, during testing, all equipment which would be damaged by test pressure. Replace removed equipment when testing has been accomplished. The system may be tested in sections as the work progresses; however, any previously tested portion shall become a part of any latter test of a composite system. Correct leaks by remaking joints with new material.

C. Test time will be accrued only while full test pressure is on the system, unless indicated otherwise. “Tolerance” shall be no pressure drop, except that due to temperature change in a 24-hour period. Inspect and test all work prior to burying or concealing. Test pressure shall be one and one-half times the system operating pressure or the listed test pressure below, whichever is greater:
<table>
<thead>
<tr>
<th>System</th>
<th>Test Medium</th>
<th>Test Pressure</th>
<th>Tolerance-Test Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Water</td>
<td>Water</td>
<td>150 psig</td>
<td>None – 8 hours</td>
</tr>
<tr>
<td>Sanitary Sewer and Gravity Condensate (non-plastic)</td>
<td>Water</td>
<td>10 ft head (or 5 psi air)</td>
<td>No leaks – 8 hours</td>
</tr>
<tr>
<td>Sanitary Sewer and Gravity Condensate (plastic)</td>
<td>Water</td>
<td>10 ft head</td>
<td>No leaks – 8 hours</td>
</tr>
<tr>
<td>Pumped Sanitary and Condensate</td>
<td>Water</td>
<td>150 psig or 150% of pump shutoff head, whichever is greater</td>
<td>None – 8 hours</td>
</tr>
<tr>
<td>Vent (non-plastic)</td>
<td>Air</td>
<td>5 psi</td>
<td>No leaks – 8 hours</td>
</tr>
<tr>
<td>Vent (plastic or non-plastic)</td>
<td>Water</td>
<td>10 ft head</td>
<td>No leaks – 8 hours</td>
</tr>
<tr>
<td>Rainwater</td>
<td>Water</td>
<td>10 ft head (or 5 psi air)</td>
<td>No leaks – 8 hours</td>
</tr>
<tr>
<td>Natural Gas/Propane/LP Gas</td>
<td>Air or Nitrogen</td>
<td>100 psig</td>
<td>None – 24 hours</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>Air</td>
<td>200 psig</td>
<td>None – 8 hours</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>Air</td>
<td>300 psig</td>
<td>None – 8 hours</td>
</tr>
</tbody>
</table>

D. Valves: Test all valve bonnets for tightness. Test operate all valves at least once from closed-to-open-to-closed position while valve is under test pressure. Test all automatic valves, including solenoid valves, and temperature and pressure relief valves, safety valves, and temperature and pressure relief valves not less than three (3) times.

E. Piping Specialties: Test all thermometers, pressure gauges, and water meters for accurate indication; automatic water feeders, air vents, trap primers, and vacuum breakers for proper performance. Test all air vent points to ensure that all air has been vented.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 220500 - Basic Plumbing Materials and Methods, and other Sections in Division 22 specified herein.

1.2 SCOPE

A. This Section specifies the requirements to furnish and install clean, dry, oil-free, and shop compressed air equipment.

B. Compressed Air Equipment:
   1. Oil-free, two stage, rotary screw, water-cooled air compressor.
   2. Heatless type regenerative desiccant compressed air dryer.
   3. Coalescing compressed air filter.
   4. Interceptor compressed air filter.
   5. Absorber compressed air filter.
   6. Sequence control panels.
   7. Drip legs.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 220500: Basic Plumbing Materials and Methods

B. Section 221000: Plumbing Piping, Valves and Specialties

C. Division 26: Electrical

1.4 QUALITY ASSURANCE

A. Comply with codes and standards required for proper system installation.

B. The compressed air equipment manufacturer shall have established an ongoing Quality Assurance/Quality Control program, including manuals available for inspection at their plant.

1.5 WORKMANSHIP

A. Install all work pertaining to compressed air equipment as close as possible to layout shown on the drawings. Employ skilled mechanics to install all systems in a manner acceptable to the owner.

1.6 SUBMITTALS

A. Prior to construction submit for approval all materials and equipment in accordance with Division 01 requirements.

B. Provide the following in addition to the standard requirements:
   1. Complete layout drawings including plan, elevations, and relevant details.
2. Complete catalog information on the compressed air equipment and accessories listed including:
   a. Motors
   b. Sequence control panel
   c. Accessories and piping
3. Control panel layout, control ladder diagram, and a written sequence of operations.
4. Factory test results and certifications

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Division 01. Deliver products to the site in containers with manufacturer’s stamp or label affixed.

B. Store/protect products under provisions of Division 01. Protect products against dirt, water, chemical, and mechanical damage. Do not install damaged products - remove from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 220500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish all required components to connect new compressed air tap to existing system including, but not limited to piping, fittings, and valves.

2.2 AIR COMPRESSOR ACCESSORIES AND PIPING

A. Provide all interconnecting piping, wiring, valves, and controls necessary for a complete air compressor equipment package. Accessories shall include, but not be limited to the following:
   1. Isolation valves at point of connection to existing system and at new tap.
   2. Pump outlet
   3. Pressure gauge

B. To assist in bid evaluation, provide a list of all other accessories not normally provided with the supplier’s standard air compressor equipment package not mentioned above.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with the manufacturer’s recommendations. Locate compressed air equipment on concrete housekeeping pad and provide connections to system piping as shown on the drawings. Provide process cooling water supply and return and piping connection as required.

B. General Requirements:
   1. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated. Anchor air
compressors to surface according to manufacturer’s written instructions and seismic criteria applicable to this project.

2. Install mechanical 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.

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

4. Install the following devices on compressed-air equipment:
   a. Thermometer, Pressure Gauge, and Safety Valve: Install on each compressed-air receiver.
   b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
   c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.2 CONNECTIONS

A. Comply with requirements for piping as specified in Section 220500: Basic Plumbing Materials and Methods and Section 221000: Plumbing Piping, Valves and Specialties. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

D. Connect water supply to compressed-air equipment that requires water including backflow preventer.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work under this Section shall comply with the requirements of General Conditions, Supplemental Conditions, Special Conditions and Division 01 - General Requirements, and shall include all Mechanical Sections specified herein.

1.2 SCOPE OF THIS SECTION

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Compliance with all codes and standards applicable to this jurisdiction
   2. Shop Drawings for Equipment
   3. Coordination Documents
   4. Record Drawings
   5. Start-up Service and Building Commissioning
   6. Instruction, Maintenance, and O & M Manuals
   7. Work associated with Delivery, Storage, and Handling of products
   8. Work associated with provision of Temporary Facilities
   9. Preparation of Posted Operating Instructions
   10. Meeting Project Safety and Indemnity requirements
   11. Proper Cleaning and Closing
   12. Supplying proper Warranty information
   13. Supply specified Guarantee documentation
   14. Design and provision of Supports and Anchors
   15. Pipe Portals
   16. Pipe Supports
   17. Equipment Rails
   18. Access Doors
   19. Identification Markers
   20. Coordination of Electrical requirements for equipment provided

1.3 DESCRIPTION OF WORK

A. The Contract Documents, including Specifications and Construction Drawings, are intended to provide all material and labor to install complete heating, ventilating, air conditioning systems for the building and shall interface with all existing building systems affected by new construction.

B. The Contractor shall refer to the architectural interior details, floor plans, elevations, and the structural and other Contract Drawings and shall coordinate this work with that of the other trades to avoid interference. The plans are diagrammatic and show generally the locations of the fixtures, equipment, and pipe lines and are not to be scaled; all dimensions and existing conditions shall be checked at the building.

C. The Contractor shall comply with the project closeout requirements as detailed in General Requirements of Division 01.

D. Where project involves interface with existing building and site systems, every effort has been made to note existing utilities and services. However, the Contractor should thoroughly familiarize themselves with existing conditions and be aware that in some cases information is
not available as to concealed conditions, which exist in portions of the existing building affected by this work.

E. The contractor shall design and supply all miscellaneous metals and system support components that are necessary to support all mechanical system, whether indicated or not on the drawings. Such metals and support components and related connections shall be provided as necessary to directly and concentrically impost loads on the primary structure. Refer to structural design requirements for specific attachment requirements. The mechanical system supports shall accommodate lateral movements between floors as defined in the story drift requirements.

F. The contractor shall design and supply mechanical devices and system components that are necessary to accommodate structural movement as defined by structural design criteria associated with ductwork and piping transitions through building expansion joints. Design of expansion joints to allow for dimensional changes in portions of a structure separated by such joints should take both reversible and irreversible movements into account.

1.4 DESCRIPTION OF BID DOCUMENTS

A. Specifications:
   1. Specifications, in general, describe quality and character of materials and equipment.
   2. Specifications are of simplified form and include incomplete sentences.

B. Drawings:
   1. Drawings in general are diagrammatic and indicate sizes, locations, connections to equipment and methods of installation.
   2. Before proceeding with work check and verify all dimensions.
   3. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
   4. Make adjustments that may be necessary or requested, in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
   5. Where existing pipes, conduits and/or ducts prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits and/or ducts. Verify exact location and elevation of existing piping prior to any construction.
   6. If any part of Specifications or Drawings appears unclear or contradictory, apply to Owner’s Representative interpretation and decision as early as possible, including during bidding period.

1.5 DEFINITIONS

A. Above Grade: Not buried in the ground and not embedded in concrete slab on ground.

B. Accessible: Ability to perform recommended maintenance without removal of services or equipment and requiring no special platforms.

C. Actuating or Control Devices: Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.

D. Below Grade: Buried in the ground or embedded in concrete slab on ground.

E. Concealed: Embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures. In general, any item not visible or directly accessible.
F. Connect: Complete hook-up of item with required service.

G. Drift: The horizontal deflection at the top of the story relative to the bottom of the story. Refer to structural design for drift dimensional movements.

H. Expansion Joint: A mid-structure separation designed to relieve stress on building materials caused by building movement induced by any of the following: thermal expansion and contraction; wind sway; seismic events; static load deflection; or live load deflection. Expansion joint systems are used to bridge the gap and maintain building assembly functions while accommodating expected movements. Expansion joints also include transitions from an existing building to a new building addition. Refer to structural design for expansion joint dimensional movements.

I. Explosion Proof Equipment (per National Electrical Code-Article 501): Equipment enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor that may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and that operates at such an external temperature that a surrounding flammable atmosphere will not be ignited thereby. Explosion proof motors are required for Class I, II or II applications regardless of Division or Group as defined in National Electrical Code – Article 501 and ANSI/ISA-12.20.01.
   1. Class I: Hazardous due to flammable gases or vapors are present or may be present in quantities sufficient to produce explosive or ignitable mixtures.
   2. Class II: Hazardous due to combustible or conductive dusts are present or may be present in quantities sufficient to produce explosive or ignitable mixture.
   3. Class III: Hazardous due to ignitable fibers are present or may be present in quantities sufficient to produce explosive or ignitable mixtures.
   4. Division: The substance referred to by Class has a high probability (Division 1) or low probability (Division 2) of producing an explosive or ignitable mixture due to it being present continuously, intermittently, or periodically or from the equipment itself under normal operating conditions.
   5. Group: Type of hazardous material in surrounding environment ranging from Group A flammable liquids to Group G combustible dusts.

J. Exposed: Not installed underground or concealed.

K. FRT: Fire retardant treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84 or UL 723, a listed flame spread index of 25 or less.

L. Furnish: To supply equipment and products as specified.

M. Indicated, Shown or Noted: As indicated, shown or noted on Drawings or Specifications.

N. Install: To erect, mount and connect complete with related accessories.

O. Motor Controllers: Manual or magnetic starters (with or without switches), individual push buttons or hand-off-automatic (HOA) switches controlling the operation of motors.

P. Must: A desire to complete the specified task. Allows some flexibility in application as opposed to Shall.

Q. Noncombustible Material: A noncombustible material is a substance that will not ignite, burn, support combustion, or release flammable vapors when subject to fire or heat in compliance with ASTM E136 Standard Test Method for Assessing Combustibility of Materials Using a
Vertical Tube Furnace at 750°C. Examples of noncombustible materials include the following, but confirm compliance in manufacturer literature:

1. Portland cement concrete, concrete, gypsum concrete (normally used in drywall or poured gypsum floor toppings), Portland cement stucco, Portland cement plaster, and gypsum plaster, gypsum wall board (sheetrock), and Type X gypsum wall board.
2. Brick masonry, concrete block masonry, and ceramic tiles.
3. Steel, stainless steel, galvanized steel, and other metals, except aluminum (aluminum is classified as limited-combustible), magnesium and magnesium alloys.
4. Sheet glass, block glass, and uncoated glass fibers.

R. NRTL: Nationally Recognized Testing Laboratory, including UL and/or ETL.

S. Piping: Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.

T. Provide: To supply, install and connect as specified for a complete, safe and operationally ready system.

U. Reviewed, Satisfactory or Directed: As reviewed, satisfactory, or directed by or to Architect/Engineer/Owner's Representative.

V. Rough-In: Provide all indicated services in the necessary arrangement suitable for making final connections to fixture or equipment.

W. Shall: An exhortation or command to complete the specified task including providing and installing work associated with task.

X. Similar or Equal: Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified products.

Y. Supply: To purchase, procure, acquire and deliver complete with related accessories.

Z. Typical or Typ: Exhibiting the qualities, traits, or characteristics that identify a kind, class, number, group or category. Of or relating to a representative specimen. Application shall apply to all other similarly identified on plan or detail.

AA. Will: A desire to complete the specified task. Allows some flexibility in application as opposed to "Shall".

BB. Wiring: Raceway, fittings, wire, boxes and related items.

CC. Work: Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.

1.6 RELATED WORK SPECIFIED ELSEWHERE

A. All Division 23 Mechanical sections included herein.

B. Division 33: Utility Site Work.
   1. Coordination of excavation of trenches and the installation of mechanical systems and piping on site.
C. Division 03: Concrete.
   1. All concrete work required for mechanical work shall be coordinated by Division 23 with Division 03 including:
      a. Concrete curbs and housekeeping pads for the mechanical equipment.
      b. Thrust blocks, pads, and boxes for mechanical equipment.

D. Division 07: Thermal and Moisture Protection.
   1. Flashing and sheet metal.
   2. Sealants and caulking.
   3. Firestopping.

E. Division 09: Painting.
   1. Division 23 shall coordinate with Division 09 to perform all painting, except where specifically stated otherwise in Division 09.
   2. Painting of all exposed steel, piping, ductwork, insulation, equipment and materials
   3. Paint all exposed gas piping, interior and exterior to the building, yellow.

F. Division 10: Miscellaneous Metals.
   1. Exterior louvers and grilles shall be included in this Section.

G. Division 26: Electrical.
   1. Power connections to all mechanical equipment

   1. Fire protection alarms and relays.
   2. Smoke detector and monitoring.
   3. Life safety systems.

1.7 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Perform all tests required by governing authorities and required under all Division 23 Sections. Provide written reports on all tests.

C. Electrical devices and wiring shall conform to the latest standards of NEC; all devices shall be UL listed and labeled.

D. All accessible mechanical work shall comply with the minimum requirements of the Americans with Disabilities Act (ADA) and local amendments. Also, refer to ICC/ANSI A117.1 Accessible and Usable Buildings and Facilities. Refer to Architectural drawings and specifications for additional ADA requirements. The following requirements are provided as consolidated list of minimum ADA requirements. Compliance requirements applicable to HVAC work includes, but is not limited to, the following:
   1. Section 309: Operable parts shall be operable with one hand and shall not require tight grasping, pinching, or twisting of the wrist. The force required to activate operable parts shall be 5 pounds maximum.
   2. Section 308.3: Temperature control devices mounted on walls with operable buttons or switches shall be placed where clear floor or ground space allows a parallel approach and the side reach is unobstructed. Operable parts shall be located 48” maximum above finished floor, and no lower than 42” above finished floor. Do not mount above light switches to avoid inaccurate temperature readings due to light switch heat output.
3. Section 308.3.2: Where a clear floor or ground space allows a parallel approach to an element and high reach is over an obstruction, the height of the obstruction shall be 34” maximum and depth of obstruction shall be 24” maximum.

4. Section 404.2.9: Fire doors shall have a minimum opening force allowable by the applicable Building Code. The force for pushing or pulling open a door other than fire doors shall be 5 pounds maximum.

E. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

F. Provide in accordance with appropriate referenced standards of the following and as referenced in other specification sections:
   1. AABC - Associated Air Balance Council
   2. ADA - Americans with Disabilities Act
   3. ADC - Air Diffuser Council
   4. AHRI - Air Conditioning, Heating and Refrigeration Institute
   5. AMCA - Air Moving and Conditioning Association
   6. ANSI - American National Standards Institute
   7. ASCE 7-10 – American Society of Civil Engineers – Minimum Design Loads for Buildings and Other Structures
   8. ASHRAE - American Society of Heating, Refrigerating & Air Conditioning Engineers
   9. ASME - American Society of Mechanical Engineers
   10. ASTM - American Society for Testing Materials
   11. AWS - American Welding Society
   12. CSA - Canadian Standards Association
   13. ETL - Electrical Testing Laboratories
   14. FM - Factory Mutual
   15. IBC - International Building Code
   16. ICC AC156 Seismic Certification by Shake-Table Testing of Nonstructural Components.
   17. MSS - Manufacturer's Standardization Society
   18. NEMA - National Electrical Manufacturer's Association
   19. NFPA - National Fire Protection Association
   20. SMACNA - Sheet Metal and Air Conditioning Contractors National Association
   21. UL - Underwriter's Laboratories

G. Provide compliance in accordance with the following referenced standard which applies to general system compliance in contrast to specific equipment standards referenced elsewhere:
   1. UL-2043: Standard for Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces. This is applicable to spaces above suspended ceilings and below raised floors.

1.8 CONFLICTING REQUIREMENTS

A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to the Owner’s Representative for a decision before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as
appropriate, for the context of requirements. Refer uncertainties to the Owner’s Representative for a decision before proceeding.

1.9 QUALITY ASSURANCE

A. Manufacturer’s Nameplates: Nameplates on manufactured items shall be metallic riveted or bolted to the manufactured item, with nameplate data engraved or punched to form a non-erasable record of equipment data suitable for the ambient exposure.

B. All work shall include the following:
   1. Manufactured items and equipment shall be a current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.

C. Experience: Unless more stringent requirements are specified in other sections of Division 23, manufactured items shall have been installed and used, without modification, renovation or repair, on other projects for not less than one year prior to the date of bidding for this project.

D. Each product and/or equipment type shall be provided by one manufacturer. Mixtures of manufacturers for each product and/or equipment type are not acceptable. Example – all fire dampers shall be supplied by one manufacturer.

E. Special Inspections: Provide structural design and Special Inspections as required in Chapter 17 of the local building code and the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. All anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

F. Welding Standards:
   1. Welding Qualifications:
      a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The welder must maintain their certification to show qualified welding experience every six months. The Owner’s Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.
   2. Welding Procedures:
      a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
      b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.”

G. Pressure Piping Standards
   1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-Building Services Piping standards for materials, products, and installation per pressure and temperature operating class.
   2. Comply with ASME B31.9 Building Services Piping standard for the following services:
      a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
      b. Fluid pressure less than 350 psig.
   3. Comply with ASME B31.1 Power Piping standard for the following services:
      a. Steam.
4. Comply with ASME B31.3 Process Piping standard for the following services:
   a. Conveying fluid above 250°F (121°C).
   b. Toxic or flammable fluids.

1.10 GENERAL REQUIREMENTS

A. Examine all existing conditions at building site.

B. Review contract documents and technical specifications for extent of new work to be provided.

C. Provide and pay for all permit, licenses, fees and inspections, including, but not limited to, building permits, planning permits, air quality management district permits, operating licenses, utility district fees, special district fees, environmental impact reports, and additional local permits and fees.

D. Prepare a Construction IAQ Management Plan meeting the SMACNA IAQ guidelines. See Section 233113 Air Distribution for a summary of requirements.

E. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing. This work shall include furnishing and installing all access doors required for mechanical access. Joints and fittings shall not be located in inaccessible locations such wall, floor and roof penetrations.

F. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected. Refer to Equipment Specifications for rough-in requirements.

G. Coordinate mechanical equipment and materials installation with other building components.

H. Ductwork and piping dimensions, as identified on drawings and in specifications, refer to the interior free dimensions. Adjust work as necessary to account for larger outside dimensions to account for material wall thickness. Upsize plastic pipe diameters as necessary to maintain minimum interior dimensions.

I. Verify all dimensions by field measurements.

J. Arrange for chases, slots, and openings in other building components to allow for mechanical installations.

K. 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.

L. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

M. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials. Contractor shall provide for all cutting and patching required for installation of this work unless otherwise noted.

N. Where mounting heights are not detailed or dimensioned, install mechanical services and overhead equipment to provide the maximum headroom possible.
O. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. Connect equipment for ease of disconnecting, without interference with other installations.

P. Coordinate the installation of mechanical materials and equipment above ceilings with ductwork, piping, conduits, suspension system, light fixtures, cable trays, sprinkler piping and heads, and other installations.

Q. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

R. Coordinate with Owner’s Representative in advance to schedule shutdown of existing systems to make new connections. Provide valves in new piping to allow existing system to be put back in service with minimum down time.

S. All materials (such as supports, gaskets, sealants, insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall be noncombustible or have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified. Coordinate with all disciplines to assure that all discrete electrical, plumbing and mechanical products located in plenums are non-combustible and compliant with UL 2043.

T. Coordinate installation of floor drains and floor sinks with work of other trades, such that finished floor slopes to drains and floor sinks are flush with surrounding floor.

U. Products made of or containing lead, asbestos, mercury or other known toxic or hazardous materials are not acceptable for installation under this Division. Any such products installed as part of the work of the Division shall be removed and replaced and all costs for removal and replacement shall be borne solely by the installing Contractor.

1.11 MINOR DEVIATIONS

A. The Drawings are diagrammatic and show the general arrangements of all mechanical work and requirements to be performed. It is not intended to show or indicate all offsets, fittings, and accessories which will be required as a part of the work of this Section.

B. The Contractor shall review the structural and architectural conditions affecting their work. It is the specific intention of this section that the contractor’s scope of work shall include:

C. Proper code complying support systems for all equipment whether or not scheduled or detailed on drawings or in these specifications

D. Minor deviations from the mechanical plans required by architectural and structural coordination.

E. The Contractor shall study the operational requirements of each system, and shall arrange work accordingly, and shall furnish such fittings, offsets, supports, accessories, as are required for the proper and efficient installation of all systems from the physical space available for use by this section. This requirement extends to the Contractor’s coordination of this section's work with the “Electrical Work”. Should conflicts occur due to lack of
coordination, the time delay, cost of rectification, demolition, labor and materials, shall be borne by the Contractor and shall not be at a cost to the Owner.

F. Minor deviations to avoid conflict shall be permitted where the design intent is not altered.

G. Advise the Owner’s Representative, in writing, in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner’s Representative of conflict.

1.12 SHOP DRAWINGS AND EQUIPMENT SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. After approval of preliminary list of materials, the Contractor shall submit Shop Drawings and manufacturer’s Certified Drawings to the Owner’s Representative for approval.

C. The Contractor shall submit approved Shop Drawings and manufacturer’s equipment cuts, of all equipment requiring connection by Division 26, to the Electrical Contractor for final coordination of electrical requirements. Contractor shall bear all additional costs for failure to coordinate with Division 26.

D. Delegated-Design Submittal: For structural pipe and equipment supports, vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic, and where required wind forces required to select vibration isolators, seismic and wind restrains, support framing members, and for designing vibration isolation bases.
   2. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment and cantilever loads. Provide base with level top surfaces with integral sloping on bottom to match support structure.

E. Submittals and Shop Drawings:
   1. Submit electronic copies of manufacturer’s submittal sheets in one (1) coordinated package per Division. Multiple submissions will not be accepted without prior approval of the Owner’s Representative. Organize submittal sheets in sequential order aligned with matching specification section numbers.
   2. Provide electronic copies of shop drawings prepared to show details of the proposed installation. Copies of contract design drawings submitted to demonstrate shop drawing compliance will not be accepted.
   3. Paper submittals will only be acceptable if specifically required by Division 01.
   4. The approved submittals shall be converted into Operations & Maintenance Manuals at the completion of the project. Refer to Division 01 for additional requirements.
1.13 COORDINATION DOCUMENTS/SHOP DRAWINGS

A. The Contractor shall prepare coordinated Shop Drawings using the same electronic format as the contract documents.
   1. The shop drawings shall serve to record the coordination of the installation and location of all HVAC equipment, ductwork, grilles, diffusers, piping, fire sprinklers, lights, audio/video systems, electrical services and all system appurtenances.
   2. The Drawings shall include all mechanical rooms and floor plans.
   3. The Drawings shall be keyed to the structural column identification system, and shall be progressively numbered. Prior to completion of the Drawings, the Contractor shall coordinate the proposed installation with the Owner’s Representative and the structural requirements, and all other trades (including HVAC, Plumbing, Fire Protection, Electrical, Ceiling Suspension, and Tile Systems), and provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances. When conflicts are identified, modify system layout as necessary to resolve. Do not fabricate, order or install any equipment or materials until coordination documents are approved by the General Contractor and Owner’s Representative.
   4. Within thirty (30) days after award of Contract, submit proposed coordination document Shop Drawing schedule, allowing adequate time for review and approval by parties mentioned above. Drawings or electronic coordination should be prepared and submitted for approval on a floor-by-floor basis to phase with building construction.

B. The coordination work shall be prepared as follows:
   1. Two dimensional AutoCAD / Revit based documents:
      a. Contractor shall prepare AutoCAD/Revit coordination drawings to an accurate scale of 1/4” = 1’-0” or larger. Drawings are to be same size as Contract Drawings and shall indicate locations, sizes and elevations above finished floor, of all systems. Lettering shall be minimum 1/8” high.
      b. Contractor shall obtain AutoCAD/Revit drawings from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the HVAC work.
      c. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
      d. Drawings shall incorporate all addenda items and change orders.
      e. Distribute drawings to all other trades and provide additional coordination as needed to assure adequate space for piping, equipment and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.
   2. Three dimensional Revit / BIM based documents (if required for project):
      a. Provide three dimensional Revit model and BIM input information locating all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
      b. Contractor shall obtain Revit model and BIM input from all other trades as required to fully coordinate the installation with architectural, structural, HVAC, plumbing, electrical, fire alarm devices, low voltage devices, and other systems that interface with and/or impact the fire protection work.
      c. Model shall indicate locations of all equipment and piping, including valves and fittings, dimensions from column lines, and bottom of pipe elevations above finished floor.
      d. Provide maintenance access clearance as required by manufacturer installation instructions and as required to meet minimum code clearances.
      e. Model shall incorporate all addenda items and change orders.
      f. Distribute Revit model and BIM input information to all other trades and provide additional coordination as needed to assure adequate space for equipment and
piping and routing to avoid conflicts. When conflicts are identified, modify system layout as necessary to resolve.

C. Advise the Owner's Representative in the event a conflict occurs in the location or connection of equipment. Bear all costs for relocation of equipment, resulting from failure to properly coordinate the installation or failure to advise the Owner's Representative of conflict.

D. Verify in field exact size, location, invert, and clearances regarding all existing material, equipment and apparatus, and advise the Owner's Representative of any discrepancies between those indicated on the Drawings and those existing in the field prior to any installation related thereto.

E. Final Coordination Drawings with all appropriate information added are to be submitted as Record Drawings at completion of project.

F. Provide copy of Record Drawings to Testing and Balancing Contractor for their use when doing their work.

1.14 REQUESTS FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 01).
   1. Coordinate and submit each RFI in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
   2. Each RFI shall address single questions and related issues only.
   3. Each RFI shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to the Owner's Design Representative.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
   1. Project name.
   2. Project number.
   3. Date.
   4. Name of Contractor.
   5. Name of Architect and/or Construction Manager.
   6. RFI number, numbered sequentially and unique.
   7. RFI subject.
   8. Specification Section number and title and related paragraphs, as appropriate.
   9. Drawing number and detail references, as appropriate.
   10. Field dimensions and conditions, as appropriate.
   11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
   12. Contractor's signature.
   13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
      a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response to each RFI, plus additional
time for Architect and General Contractor to review and forward. Each RFI received by Engineer after 1:00 p.m. will be considered as received the following business day.

1. The following Contractor-generated RFIs will be returned without action:
   a. Incomplete RFIs or inaccurately prepared RFIs.
   b. RFIs submitted without indication of review and approval for submission by General Contractor or Construction Manager.
   c. RFIs addressing multiple unrelated issues.
   d. Requests for approval of submittals.
   e. Requests for approval of substitutions.
   f. Requests for approval of Contractor’s means and methods.
   g. Requests for information already indicated in the Contract Documents.
   h. Requests for adjustments in the Contract Time or the Contract Sum.
   i. Requests for interpretation of Engineer’s actions on submittals.

2. Engineer’s action may include a request for additional information, in which case Engineer’s time for response will date from time of receipt of additional information.

1.15 RECORD DOCUMENTS

A. Maintain set of Coordination Documents (drawings and specifications) marked “Record Set” at the job site at all times and use it for no other purpose but to record on it all the changes and revisions during construction.

B. Record Drawings shall indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e. – valves, traps, strainers, expansion compensators, tanks, etc.).

C. Record Specifications shall indicate approved substitutions; Change Orders; and actual equipment and materials provided.

D. Provide copy of Record Documents to Testing and Balancing Contractor and Commissioning Agent for use when performing their work.

E. At the completion of the construction transfer all “Record Set” notations to a clean set of drawings and specifications in a neat and orderly fashion that incorporates all site markups to clearly show all changes and revisions to the Contract Documents. Submit copies of Record Documents and CD/DVD disks labeled with all drawings and specifications and other supporting documentation.

F. Refer also to Division 01 for full scope of requirements.

1.16 START-UP SERVICE AND BUILDING COMMISSIONING

A. Prior to start-up, be assured that systems are ready, including checking the following: Proper equipment rotation, proper wiring, auxiliary connections, lubrication, venting, controls, and installed and properly set relief and safety valves.

B. Provide services of factory-trained technicians for start-up of air conditioning units, temperature controls, chillers, boilers, pumps, and other major pieces of equipment. Certify in writing compliance with this Paragraph, stating names of personnel involved and the date work was performed.
C. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

D. Refer to other Division 23 Sections for additional requirements.

1.17 INSTRUCTION, MAINTENANCE, AND O&M MANUALS

A. O&M Manuals: Upon completion of the work, and prior to training of Owner’s personnel, the Contractor shall submit to the Owner’s Representative complete set of operating instructions, maintenance instructions, part lists, and all other bulletins and brochures pertinent to the operation and maintenance for equipment furnished and installed as specified in this section, bound in a durable binder. Refer to Division 01.

B. Contractor shall be responsible for providing proper instruction of the of Owner’s personnel for operation and maintenance of equipment, and apparatus installed as specified in Division 23. Training is to be appropriate to the complexity of the equipment. The Contractor shall develop and submit training materials prior to this training. These materials shall include qualifications of the trainer, training agenda, learning objectives, and a written test to be administered at the end of the training session. Operation and Maintenance manuals must present, incorporated and referenced in the training sessions.

1.18 DELIVERY, STORAGE AND HANDLING

A. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, and handling.

B. Store equipment and materials in an environmentally controlled area at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage. Piping and equipment showing signs of rust shall be removed from site and replaced with new.

1.19 UNIT PRICING SUBMITTALS

A. Prior to construction submit for review all materials and equipment in accordance with Division 01 requirements.

B. Preliminary List of Materials and Unit Price Items: Within thirty (30) days after awarding of the Contract, submit to Owner’s Representative for preliminary approval a complete list of manufacturer’s names and model numbers of proposed materials and equipment. Also include proposed list of unit price items for review.
   1. Indicate substituted items.
   2. Identify test and balancing agency.
   3. Identify independent testing laboratory for water analysis.

C. The Contractor shall submit with preliminary list of materials a unit price list for each item furnished on this project. Included with price shall be labor cost index.

D. Submittals and Shop Drawings shall be submitted as a complete package bound in a 3-ring binder with tabs for each specification section. Submit six (6) typed copies of submittals. Refer to Division 01 for additional requirements.
1.20 POSTED OPERATING INSTRUCTIONS

A. Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation personnel. The operating instructions shall include wiring diagrams, control diagrams, and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. Attach or post operating instructions adjacent to each principal system and equipment including start-up, operating, shutdown, safety precautions and procedure in the event of equipment failure. Provide weather-resistant materials or weatherproof enclosures for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal.

1.21 SAFETY AND INDEMNITY

A. The Contractor shall be solely and completely responsible for conditions of the job site including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal hours of work.

B. No act, service, Drawing, review, or Construction Review by the Owner’s Representative, Architect, the Engineers or their consultants, is intended to include the review of the adequacy of the Contractor’s safety measures, in, on, or near the construction site.

C. The Contractor performing work under this Division of the Specifications shall hold harmless, indemnify and defend the Owner, the Architect, the Engineers and their consultants, and each of their officers, employees and agents from any and all liability claim, losses or damage arising, or alleged to arise from bodily injury, sickness, or death of a person or persons, and for all damages arising out of injury to or destruction of property arising directly or indirectly out of, or in connection with, the performance of the work under the Division of the Specifications, and from the Contractor’s negligence in the performance of the work described in the Construction Contract Documents; but not including the sole negligence of the Owner’s Representative, the Architect, the Engineers, and their consultants or their officers, employees and agents.

1.22 CLEANING AND CLOSING

A. All work shall be inspected, tested, and approved before being concealed or placed in operation.

B. Upon completion of the work, all equipment installed as specified in this section, and all areas where work was performed, shall be cleaned to provide operating conditions satisfactory to the Owner’s Representative.

1.23 WARRANTIES

A. Refer to general terms and conditions, as well as warranties and obligations defined in Division 1 of the specifications that provide basic warranty requirements for the entire project.

B. The warranties and corrective obligations provided under this section (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer, (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced and (iii) are
made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

C. All equipment and systems shall be provided with a minimum one-year warranty, or longer, as defined in each subsequent specification section. Warranty shall include all parts, material, labor and travel.

D. Warranty Start Date: The start date for all warranty periods shall be defined as starting from the date of Substantial Completion which shall include the Certificate of Occupancy from the Authority Having Jurisdiction.

E. Refer to individual Specification sections for additional extended warranty requirements.

F. Provide complete warranty information for each item, to include product or equipment, date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, telephone numbers and procedures for filing a claim and obtaining warranty services.

G. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

H. Service during warranty period: Contractor shall provide maintenance as specified elsewhere during the 12-month warranty period.

1.24 GUARANTEE

A. The Contractor shall guarantee and service all workmanship and materials to be as represented by him and shall repair or replace, at no additional cost to the Owner, any part thereof which may become defective within the period of one (1) year, minimum, after Substantial Completion, ordinary wear and tear excepted.

B. Contractor shall be responsible for and pay for any damages caused by or resulting from defects in this work.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

B. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers’ names used herein, unless specifically noted that substitutes are not allowed.

2.2 SUPPORTS AND ANCHORS

A. General: Comply with applicable codes pertaining to product materials and installation of supports and anchors, including, but not limited to, the following:
   1. UL and FM Compliance: Provide products, which are UL listed and FM approved.
   3. MSS Standard Compliance: Manufacturer's Standardization Society (MSS).
5. NFPA: Pamphlet number 13 and 14 for fire protection systems.
6. Provide copper plated or plastic coated supports and attachment for copper piping systems. Field applied coatings or tape is unacceptable.

B. Horizontal Piping Hangers and Supports: Except as otherwise indicated, provide factory-fabricated hangers and supports of one of the following MSS SP-58 types listed.
   1. Adjustable Steel Clevis Hangers: MSS Type 1.
   2. Adjustable Steel Swivel Band Hangers: MSS Type 10.
   4. Pipe Slides and Slide Plates: MSS Type 35, including one of the following plate types:
      a. Plate: Unguided type.
      b. Plate: Guided type.
      c. Plate: Hold-down clamp type.
   5. Pipe Saddle Supports: MSS Type 36, including steel pipe base support and cast iron floor flange.
   6. Pipe Saddle Supports with U-Bolt: MSS Type 37, including steel pipe base support and cast iron floor flange.
   7. Adjustable Pipe Saddle Supports: MSS Type 38, including steel pipe base support and cast iron floor flange.
   8. Upper Attachment Side Beam Bracket: MSS Type 34
   9. Upper Attachment Side Beam Angle Bracket: MSS Type 34, UL listed and FM Approved.
   10. Single Pipe Roller with Malleable Sockets: MSS Type 41. Rollers are not required for hydronic piping where spring hangers are utilized.
   11. Adjustable Roller Hangers: MSS Type 43. Rollers are not required for hydronic piping where spring hangers are utilized.
   12. Pipe Roll Stands: MSS Type 44.
   13. Pipe Guides: Provide factory-fabricated guides of cast semi-steel or heavy fabricated steel, consisting of a bolted two-section outer cylinder and base with a two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

C. Horizontal Cushioned Pipe Clamp: Where pipe hangers are called out to absorb vibration or shock install a piping clamp with thermoplastic elastomer insert. Cush-A-Clamp type by many manufacturers.

D. Vertical Piping Clamps: Provide factory-fabricated two-bolt vertical piping riser clamps, MSS Type 8 and or four-bolt riser clamps for heavy loads, MSS Type 42. Provide with 1" thick (minimum) neoprene pad on floor with 1/4" thick steel plate to distribute riser clamp weight to pad.

E. Hanger-Rod Attachments: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments of one of the following MSS types listed.
   1. Steel Turnbuckles: MSS Type 13.
   2. Steel Clevises: MSS Type 14.
   3. Swivel Turnbuckles: MSS Type 15.
   5. Steel Weldless Eye Nuts: MSS Type 17.
F. Building Attachments: Except as otherwise indicated by the Structural Engineering design, provide factory-fabricated building attachments of one of the following types listed.
   1. Concrete Inserts:
      a. MSS Type 18.
      b. Manufacturers: Hilti #KCS-MD (for metal deck) or HCl-WF (for wood forms), Simpson Strong Tie #Blue Banger Hanger, Powers Fasteners #Bang-It (for metal deck) or #Wood-Knocker (for wood forms), or equal.
   2. Steel Brackets: One of the following for indicated loading:
      b. Medium Duty: MSS Type 32.
      c. Heavy Duty: MSS Type 33.
   3. Horizontal Travelers: MSS Type 58.
   4. Concrete Screw Anchors: For floor mounted attachments with maximum allowable pullout and shear force of 250 lbs. (1.1 kN) per anchor regardless of size.
      a. Manufacturers: Hilti #Kwik Hus EZ-I, Simpson Strong-Tie #Titen HD (or Rod Hanger version), Powers Fasteners #Wedge-Bolt+ (Screw Anchor), Powers Fasteners #Vertigo+ (Rod Hanger), Powers Fasteners #Snake+ (Internally Threaded Screw Anchor), or equal.
   5. Torque-Controlled Expansion Anchor:
      a. Manufacturers: Hilti #Kwik Bolt TZ, Simpson Strong Tie #Strong-Bolt 2, Powers Fasteners #Power-Stud+ SD1 or Power-Stud+ SD2, or equal.
   6. Screws and Bolts:
   7. Eye Bolts:
   8. Powder-Driven Concrete Anchors:
      a. Only for existing concrete structures with minimum 4000 psi concrete compressive strength.
      b. Minimum embedment of 1" (25 mm).
      c. Maximum allowable load of 50 lbs (0.2 kN) per anchor.
      d. Manufacturer: Hilti #X or D Series, Powers Fasteners #CSI Series, or equal.

G. Saddles and Shields: Except as otherwise indicated, provide saddles or shields under piping at hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with adjacent pipe insulation.
   1. Pipe Covering Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
   2. Insulation Protection Shields: MSS Type 40, 18" minimum, or of the length recommended by manufacturer to prevent crushing of insulation. High-density insulation insert lengths shall match or exceed shield length.
   3. Thermal Hanger Shields: Constructed of 360° insert of waterproofed calcium silicate (60 psi flexural strength minimum) encased in 360° sheet metal shield. Provide assembly of same thickness as adjoining insulation. Shield length shall match or exceed length of calcium silicate insert.
      a. Pre-manufactured insulated pipe shields are an acceptable alternate where installed per manufacturer’s instructions for pipe sizes to 6” diameter. Manufacturers: SnappItz, Armacell #ArmaFix Ecolight or equal.
   4. Thermal Hanger Couplings: Constructed of high strength plastic coupling to retain uninsulated tubing at clevis hangers and strut-mounted clamps.
      a. Manufacturers: Hydra-Zorb #Klo-Shure Insulation Couplings or equal.

H. Miscellaneous Materials:
   1. Metal Framing: Provide products complying with NEMA STD ML1.
   2. Steel Plates, Shapes, and Bars: Provide products complying with ASTM A36.
3. Cement Grout: Portland Cement (ASTM C150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C404, Size No. 2). Mix at a ratio of one-part cement to three-parts sand by volume, with minimum amount of water required for placement and hydration.

4. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required. Weld steel in accordance with AWS standards.

5. Pipe Brackets: Copper plated brackets and supports for various mounting options. Insulate brackets attached to metal studs with felt. 
a. Manufacturers: Holdrite or equal.

2.3 PIPE PORTALS

A. Where pipe portals are not provided by other sections of Specification, provide prefabricated insulated pipe portals as required for piping penetrating through the roof where shown on plans. Field built pipe portals are acceptable alternatives - provide detail of construction for review.

B. Standard pipe portals, unless otherwise noted, shall be constructed as follows:
   1. Curb shall be constructed of heavy gauge galvanized steel with continuous welds on shell seams.
   2. Insulation to be 1-1/2" thick, 3 lb. density rigid fiberglass.
   3. Curb to have a raised 3" (minimum), 45° cant.
   4. Curb to have 1-1/2" x 1-1/2" wood nailer (minimum).
   5. Curb height to be 8" (minimum) above roof deck.
   6. Cant strips shall be raised to match roof insulation thickness.
   7. Cover or flashing to be constructed of galvanized steel or other suitable material to provide sturdy weather tight closure. Provide collars and rubber nipples with draw bands of sizes required by piping. Size curb, cover and nipples per manufacturer's recommendations.

C. Manufacturer: Roof Products Systems, Pate, or equal.

2.4 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping. Coordinate all pipe stands with structural design. Select stands for rated support weight and spacing. Refer to details on drawings for permanent fixed roof support and curbs.

B. Compact Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
   4. Hardware: Galvanized or stainless steel.
   5. Pipe Stand Manufacturers: Dura-Blok, Roof Top Blox, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   6. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.
C. Single-Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
   4. Vertical Members: Two, galvanized or stainless steel, continuous-thread 1/2-inch (12-mm) rods.
   5. Horizontal Member: Adjustable horizontal, galvanized or stainless-steel pipe support channels.
   6. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
   7. Hardware: Galvanized or stainless steel.
   8. Pipe Stand Manufacturers: Dura-Blok, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   9. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed of spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.

D. Multiple-Pipe Stand:
   1. Adjustable strut-based support stands shall only be used as intermediate support points between permanent fixed stands/supports as required to prevent pipe from sagging.
   2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
   3. Base: Two or more, vulcanized rubber, molded polypropylene, or polycarbonate.
   4. Vertical Members: Two or more, galvanized or stainless steel, channels.
   5. Horizontal Member: Two or more, adjustable height, galvanized or stainless-steel pipe support slotted channels or plates.
   6. Pipe Supports: Roller, strut clamps, clevis hanger or swivel hanger.
   7. Hardware: Galvanized or stainless steel.
   8. Pipe Stand Manufacturers: Dura-Blok, Roof Products Systems, nVent CADDY Pyramid, Portable Pipe Hangers, or equal.
   9. Accessories: Mount on protective roof pad with a minimum of 6" material extending beyond all edges to allow for future pipe movement. Nonwoven pad shall be constructed of spaghetti-like strands of flexible plastic with UV inhibitor and rated for -40°F to 180°F (-40°C to +82°C). Manufacturer: Yellow Spaghetti or equal.

E. Curb and Rail-Mounted Type Pipe Stands:
   1. Shop- or field-fabricated pipe supports made from structural-steel shapes, channels, continuous-thread rods, with rollers, strut clamps, clevis hangers or swivel hangers for mounting on permanent stationary roof curbs.
   2. Coordinate with structural design and mechanical details for attachment through membrane.
   3. Manufacturer: Pate, Thybar, ThyCurb, Roof Products Systems, Protech, FastCurbs, or equal.

2.5 EQUIPMENT/PIPING RAILS

A. Where equipment/pipe rails are not provided by other sections of Specification, provide prefabricated reinforced equipment rails as required for support of equipment and piping. Field built curbs are acceptable alternatives - provide detail of construction for review.

B. Standard equipment rail, unless otherwise noted, shall be constructed as follows:
   1. Construct of heavy gauge galvanized steel with continuous welds on shell seams.
2. Provide internal reinforcing supports welded as required to meet application requirements.
3. Equipment rails to have raised 3" (minimum), 45° cant.
4. Equipment rails to have 1-1/2" x 1-1/2" wood nailer (minimum) and counterflashing.
5. Equipment rail height to be 6" (minimum) above roof deck.
6. Cant shall be raised to match roof insulation thickness.

C. Equipment rails to be constructed to meet equipment size and weight requirements. Provide tapered rails to match roof pitch where required. Coordinate with structural design and mechanical details for attachment through membrane.

D. Manufacturer: Pate, Thybar, ThyCurb, Roof Products Systems, or equal.

2.6 ACCESS DOORS FOR WALL AND CEILING APPLICATIONS

A. Provide all access doors and panels to service equipment under this work, including those which must be installed, in finished architectural surfaces. Refer to other specification sections for specific access doors associated with ductwork and equipment.

B. Construction:
   1. Frame: 16-gauge steel (minimum).
   2. Door: 16-gauge steel (minimum) or two layers of 20-gauge steel (minimum) for double wall door construction.
   3. Hinge: 1" flange width, continuous piano hinge.
   4. Latching System: screwdriver latch, allen key latch or T-handle latch for non-public access areas. Cylinder key lock for public access areas. Cam latch for access to fire/life safety systems.
   5. Paint: white prime coated.

C. Size:
   1. Access doors shall be of a size to permit access and removal of equipment for servicing. Access door shall have same rating as the wall or ceiling in which it is mounted. Provide access panel for each trap primer, concealed valve, fire and combination fire/smoke dampers, volume dampers, and other equipment requiring access. Use no panel smaller than 12" x 12" for simple manual access, or smaller than 24" x 24" where personnel must pass through.

D. Architectural Coordination:
   1. Refer to Division 01 Architectural specifications and drawings for additional requirements for each surface. Contractor is to submit schedule of access panels for approval. Exact size, number and location of access panels are not shown on Plans.
   2. Included under this work is the responsibility for verifying the exact location and type of each access panel or door required to service equipment under this work and in the proper sequence to coordinate with construction schedule and with prior approval of the Owner’s Representative.
   3. Access doors in fire rated partitions and ceilings shall carry all label ratings as required to maintain the rating of the rated assembly.
   4. Submit markup of architectural plans showing size and location of access panels required for equipment access for approval by Owner’s Representative.

E. Manufacturers: Milcor, Karp, Nystrom, Elmdor/Stoneman, Durodyne, Austin Hardware, or equal.
2.7 IDENTIFICATION MARKERS

A. Mechanical Identification Materials: Provide products of categories and types required for each application as referenced in other Division 23 Sections. Where more than single type is specified for application, selection is installer's option, but provide single selection for each product category. Stencils, hand printed, painted, and felt pen markers are not acceptable.

B. Plastic Pipe Markers:
1. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially or fully cover the circumference of pipe, or insulated pipe, and to attach to pipe without fasteners or adhesive complying with ANSI A13.1. Minimum letter size shall be 1/2" high.
2. Pressure Sensitive Type: Provide pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers, complying with ANSI A13.1. Secure both ends of markers with color coded adhesive vinyl tape.
3. Insulation: Furnish 1" thick molded fiberglass insulation with jacket for each plastic pipe marker to be installed on uninsulated pipes subjected to fluid temperatures of 125°F (52°C) or greater. Cut length to extend 2" beyond each end of plastic pipe marker.
4. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.
5. Nomenclature shall include service type and directional arrow as follows:
   c. Condenser Water Supply and Return: green background with white lettering.
   d. Heat Pump Loop Supply and Return: green background with white lettering.
   e. Refrigerant: yellow background with black lettering.
   f. Exhaust air: blue background with white lettering.
   g. Other piping services: Comply with ANSI and ASME A13.1 standards.
   h. Direction of water flow.

C. Plastic Duct Markers:
1. Provide duct labels to indicate the system and direction of flow. Submit a labeling product that is suitable for the surface to be labeled.
   a. Pressure sensitive, 16" long by 2-1/4" high (minimum), 3 mil thick high gloss adhesive backed vinyl, 1-1/2" high letters, and color coded per ducted service.
2. Nomenclature shall include service type and directional arrow as follows:
   a. Supply air (cold service): green background with white lettering.
   b. Supply air (hot service): yellow background with black lettering.
   c. Return air: blue background with white lettering.
   d. Relief air: blue background with white lettering.
   e. Outside air: blue background with white lettering.
   f. Exhaust air: blue background with white lettering.
   g. Other air services: Comply with ANSI and ASME A13.1 standards.
   h. Direction of air flow.

D. Valve Tags:
1. Brass Valve Tags: Provide 1-1/2" diameter 19-gauge polished brass valve tags with stamp-engraved piping system abbreviation in 1/4" high letters and sequenced valve numbers 1/2" high, and with 5/32" hole for fastener. Fill tag engraving with black enamel.
2. Plastic Laminate Valve Tags (indoors only): Provide 3/32" thick engraved plastic laminate valve tags, with piping system abbreviations in 1/4" high letters and sequenced valve number 1/2" high, and with 5/32" hole for fasteners.
3. Valve Tag Fasteners: Provide solid brass chain (wire link or beaded type), or solid brass S-hooks of the sizes required for proper attachment of tags to valves and manufactured specifically for that purpose.

E. Access Panel Markers: Provide 1/16” thick (minimum) engraved plastic laminate access panel markers, with abbreviations and numbers corresponding to concealed valve or device.

F. Plastic Equipment Signs:
   1. Provide 4-1/2” x 6” (minimum) plastic laminate sign, ANSI A.13 color coded with engraved white core lettering. Minimum letter size shall be 1/2” high.
   2. Fasteners: Self-tapping stainless steel screws, except contact-type permanent adhesive where screws cannot or should not penetrate the substrate.
   3. Nomenclature: Include the following, matching terminology on schedules as closely as possible:
      a. Tag number
      b. Equipment service.
      c. Design capacity.
      d. Other design parameters, such as pressure drop, entering and leaving conditions, rpm, etc.
   4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2”x11” bond paper, tabulate each equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

G. Underground-Type Plastic Line Markers: Provide 6” wide x 4 mils thick multi-ply tape, consisting of solid metallic foil core between 2 layers of plastic tape. Markers to be permanent, bright colored, continuous printed, intended for direct burial service.

H. Acceptable Manufacturers: Craftmark, Seton, Brady, Marking Services, Kolbi, or Brimar.

2.8 ELECTRICAL

A. General:
   1. All electrical material, equipment, and apparatus specified herein shall conform to the requirements of Division 26.
   2. Provide all motors for equipment specified herein. Provide motor starters, controllers, and other electrical apparatus and wiring which are required for the operation of the equipment specified herein.
   3. Set and align all motors and drives in equipment specified herein.
   4. Provide expanded metal or solid sheet metal guards on all V-belt drives to totally enclose the drive on all sides. Provide holes for tachometer readings. Support guards separately from rotating equipment.
   5. Provide for all rotating shafts, couplings, etc., a solid sheet metal, inverted “U” cover over the entire length of the exposed shaft and support separately from rotating equipment. Cover shall extend to below the bottom of the shaft and coupling, and shall meet the requirements of the State Industrial Safety Regulations.
   6. Specific electrical requirements (i.e., horsepower and electrical characteristics) for mechanical equipment are scheduled on the Drawings.

B. Quality Assurance:
   1. Electrical components and materials shall be UL or ETL listed/labeled as suitable for location and use - no exceptions.
C. Motors:
   1. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment Specifications.
   2. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads.
   3. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range. Unless otherwise noted on plans, all motors 3/4 HP and larger shall be rated for 3-phase operation above 200 volts. Unless otherwise noted on plans, all motors up to 1/2 HP shall be rated for 120-volt, single phase operation.
   4. Temperature Rating: Motor meets class B rise with class F insulation.
   5. Service Factor: 1.15 for poly-phase motors and 1.35 for single phase motors.
      a. Frames: NEMA Standard No. 48 or 56; use driven equipment manufacturer’s standards to suit specific application.
      b. VFD driven motors to be provided as inverter ready and equipped with a shaft grounding device.
      c. Bearings:
         1) Ball or roller bearings with inner and outer shaft seals.
         2) Re-greaseable, except permanently sealed where motor is normally inaccessible for regular maintenance.
         3) Designed to resist thrust loading where belt drives or other drives product lateral or axial thrust in motor.
         4) For fractional horsepower, light duty motors, sleeve type bearings are permitted.
         5) Enclosure type for various applications:
            (a) Open drip-proof (ODP) motors for indoor use in clean air environments.
            (b) Totally enclosed fan cooled (TEFC) motors for outdoor use and indoor application in dirty environments.
            (c) Totally enclosed air over (TEAO) motors for motors in the airstream of cooling towers and fluid coolers.
            (d) Explosion proof motors where motor is located in environments with hazardous or flammable quantities of vapors, gases, mists or dusts or where motor is located inside ductwork or cabinets with hazardous vapors, gases, mists or dusts that exceed 25 percent of the lower flammability limit.
            (e) Guarded drip-proof motors where exposed to contact by employees or building occupants.
            (f) Weather protected Type I for outdoor use, Type II where not housed.
            (g) Electronically commutated motor (ECM) for indoor use in clean air environments.
      d. Overload Protection: Built-in thermal overload protection where external overload protection is not provided and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.
      e. Noise Rating: “Quiet.”
      f. Efficiency:
         1) Motors shall have a minimum efficiency per governing State or Federal codes, whichever is higher.
         2) And, motors shall meet the NEMA premium efficiency standard.
      g. Nameplate: Indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

D. Starters and Electrical Devices:
   1. Motor Starter Characteristics:
      a. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs.
b. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

2. Manual switches shall have pilot lights and all required switch positions for multi-speed motors. Overload Protection: Melting alloy or bi-metallic type thermal overload relays, sized according to actual operating current (field measured).

3. Magnetic Starters:
   a. Heavy duty, oil resistant, hand-off-auto (HOA), or as indicated, and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
   b. Trip-free thermal overload relays, each phase, sized according to actual operating current (field measured).
   c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division 23 Controls sections.
   d. Built-in primary and secondary fused control circuit transformer, supplied from load side of equipment disconnect.
   e. Externally operated manual reset.
   f. Under-voltage release or protection for all motors over 20 hp.

4. Motor Connections: Liquid tight, flexible conduit, except where plug-in electrical cords are specifically indicated.

E. Low Voltage Control Wiring:
   1. General: 14-gauge, Type THHN, color coded, installed in conduit.
   2. Manufacturer: General Cable Corp., Alcan Cable, American Insulated Wire Corp., Senator Wire and Cable Co., or Southwire Co.

F. Disconnect Switches:
   1. Fusible Switches: For equipment 1/2 HP or larger, provide fused, each phase; heavy duty; horsepower rated; spring loaded quick-make, quick-break mechanism; dead front line side shield; solderless lugs suitable for copper or aluminum conductors; spring reinforced fuse clips; electro silver plated current carrying parts; hinged doors; operating lever arranged for locking in the “OPEN” position; arc quenchers; capacity and characteristics as indicated.
   2. Non-Fusible Switches: For equipment less than 1/2 horsepower, switch shall be horsepower rated; toggle switch type with thermal overload quantity of poles and voltage rating as required.

PART 3 EXECUTION

3.1 GENERAL

A. Workmanship shall be performed by licensed journeymen or master mechanics and shall result in an installation consistent with the best practices of trades.

B. Install work uniform, level and plumb, in relationship to lines of building. Do not install any diagonal, or otherwise irregular work unless so indicated on Drawings or as approved by Owner’s Representative.

3.2 MANUFACTURER’S DIRECTIONS

A. Follow manufacturers’ directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications.
   1. If the contractor must deviate from the manufacturer’s recommendations provide a letter from the manufacturer indicating the clearance to be provided is acceptable for scheduled performance and maintenance.
3.3 INSTALLATION

A. Coordinate the work between the various Mechanical Sections and with the work specified under other Divisions. If any cooperative work must be altered due to lack of proper supervision or failure to make proper and timely provisions, the alternations shall be made to the satisfaction of the Engineer and at the Contractor’s cost. Coordinate wall and ceiling work with the General Contractor, and other trades in locating ceiling air outlets, wall registers, etc.

B. Inspect all material, equipment, and apparatus upon delivery and do not install any damaged or defected materials.

3.4 SUPPORTS AND HANGERS

A. Prior to installation of hangers, supports, anchors, and associated work, installer shall meet at project site with the General Contractor, installer of each component of associated work, inspection and testing agency representatives, (if any), installers of other work with requirements specified.

B. Installation of Building Attachments: Install building attachments at required locations within concrete or on structural steel for proper piping support. Install additional building attachments where support is required for additional concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed. Fasten insert securely to forms. Where Gypcrete is indicated, install reinforcing bars through opening at top of inserts. Inserts and anchors shall be located no closer than 6” to any edge and no closer than 1” from any pre-tension cables or embedded steel and as required per manufacturer’s instructions and Structural Engineer.

C. Proceed with installation of hangers, supports, and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including, but not limited to, proper placement of inserts, anchors, and other building structural attachments.

D. Install hangers, supports, rails, clamps, and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal piping to be supported together on trapeze type hangers and rails where possible. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

E. Install pipe supports (hangers, rails, etc.) within 12 inches of every change in piping direction (only one support required at each change in direction), end of pipe run or concentrated load, and within 36 inches of every major piece of equipment. Supports (hangers, rails, etc.) shall be installed on both sides of flexible connections. Where flexible connection connects directly to a piece of equipment only one support is required.

F. Install hangers, rails, and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

G. Support sprinkler piping and gas independently of other piping.

H. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.
I. Hanger Spacing in accordance with following minimum spans for support of individual pipes. Install a minimum of one hanger within 12” of each change of direction (only one required on either side of elbow), at the end of deadend pipe runs and within 36” of every piece of equipment. For straight runs of horizontal piping with no concentrated loads such as valves, flanges, expansion joints, or other components. Sections of piping with concentrated loads will have to be considered carefully and a determination made as to appropriate spacing and rod size for the given situation. Other spacing and rod sizes may be considered in compliance with Table 121.5 of ASME B31.1, ANSI/MSS SP-58 Table 4, and local mechanical code, but shall not exceed 12 feet for any pipe size. Comply with more restrictive requirements of local codes where those exceed the following minimum criteria.

1. Steel Pipe:

<table>
<thead>
<tr>
<th>Steel Pipe Size</th>
<th>Hanger/Support Spacing (Maximum)</th>
<th>Rod Size (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2” to 1”</td>
<td>7 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>1-1/4” to 2-1/2”</td>
<td>10 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>3” to 4”</td>
<td>12 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>5” to 8”</td>
<td>12 feet</td>
<td>1/2”</td>
</tr>
<tr>
<td>10” to 12”</td>
<td>12 feet</td>
<td>5/8”</td>
</tr>
<tr>
<td>14” to 16”</td>
<td>12 feet</td>
<td>3/4”</td>
</tr>
</tbody>
</table>

2. Copper Pipe:

<table>
<thead>
<tr>
<th>Copper Pipe Size</th>
<th>Hanger/Support Spacing (Maximum)</th>
<th>Rod Size (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2”</td>
<td>4 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>3/4” to 2”</td>
<td>6 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>2-1/2” to 4”</td>
<td>8 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>5” to 8”</td>
<td>8 feet</td>
<td>1/2”</td>
</tr>
</tbody>
</table>

3. Plastic/Fiberglass Pipe:

<table>
<thead>
<tr>
<th>Plastic/Fiberglass Pipe Size</th>
<th>Hanger/Support Spacing (Maximum)</th>
<th>Rod Size (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1”</td>
<td>3 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>1-1/4” to 2-1/2”</td>
<td>4 feet</td>
<td>3/8”</td>
</tr>
<tr>
<td>3” to 8”</td>
<td>4 feet</td>
<td>1/2”</td>
</tr>
</tbody>
</table>

4. Trapeze support: Provide details stamped by a Registered Structural Engineer for the project state indicating trapeze channels, support rod sizes, and spacing.

5. Maximum threaded rod loading: Below are maximum loads for hanger rods based on ASHRAE Fundamentals Handbook (Pipe Design Chapter) and ASTM A36, with a safety factor.

<table>
<thead>
<tr>
<th>Nominal Rod Diameter</th>
<th>Load (Maximum Weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/8”</td>
<td>610 pounds</td>
</tr>
<tr>
<td>1/2”</td>
<td>1,130 pounds</td>
</tr>
<tr>
<td>5/8”</td>
<td>1,810 pounds</td>
</tr>
<tr>
<td>3/4”</td>
<td>2,710 pounds</td>
</tr>
<tr>
<td>7/8”</td>
<td>3,770 pounds</td>
</tr>
<tr>
<td>1”</td>
<td>4,960 pounds</td>
</tr>
</tbody>
</table>
J. Provisions for Movement:
   1. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
   2. Load Distribution: Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connecting equipment.
   3. Insulated Piping: Comply with the following installation requirements:
      a. Clamps: Attach clamps, including spacers, (if any), to piping with clamps projecting through insulation.
      b. Shields: Where low compressive strength insulation or vapor barriers are indicated on cold or chilled water piping, install shields or inserts.
      c. Saddles: Where insulation without vapor barrier is indicated install protection saddles.

K. Installation of Anchors:
   1. Install anchors at proper locations to prevent excessive stresses and to prevent transfer of loading and stresses to connected equipment.
   2. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure.
   3. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to limit movement of piping and forces to maximums recommended by manufacturer for each unit.
   4. Anchor Spacing: Where not otherwise indicated, install anchors at ends of principal pipe runs and at intermediate points in pipe runs between expansion loops and bends.

L. 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.

M. Equipment Supports:
   1. Provide all concrete bases, unless otherwise furnished as work of Division 03. Furnish to Division 03 Contractor scaled layouts of all required bases, with dimensions of bases, and location to column centerlines. Furnish templates, anchor bolts, and accessories necessary for base construction. Coordinate size of concrete pads and placement of anchors bolts with structural design. Anchor bolts shall be placed to maintain 6", minimum, or greater distance from concrete pad edges.
   2. Provide structural steel stands to support equipment above floor mounted or suspended from structure. Construct of structural steel members or steel pipe and fittings. Provide factory-fabricated tank saddles for tanks.
N. Adjusting:
1. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments.
2. Support Adjustment: Provide grout under supports to align piping and equipment to proper level and elevations.
3. Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

O. Upper Building Attachments: Powder-actuated fasteners may be used where appropriate for construction materials to which hangers are being attached per the following:
1. Maximum allowable tension load shall not exceed 50 lbs. (0.2 kN) per attachment.
2. May only be used to supporting for ductwork up to two (2) square feet (0.2 m²) in cross sectional area and for control conduit clips.
3. May not be used for support of any piping, equipment, or ductwork greater than two (2) square feet (0.2 m²) in cross sectional area.
4. Use concrete inserts before placing concrete in new construction.
5. Install powder-actuated concrete fasteners after concrete is placed and completely cured to concrete compressive strength of 4000 psi or greater.
6. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
7. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
8. Do not use powder-actuated concrete fasteners for seismic restraints.

3.5 WALL, FLOOR, AND ROOF PENETRATIONS

A. All pipe and duct penetrations through rated and non-rated assemblies shall be sized to allow for compliance with structural integrity and fire ratings, as applicable. Penetrations of fire-resistance-rated assemblies shall be protected by an approved firestop system installed and tested in accordance with ASTM E814 or UL 1479. The system shall have an F rating/T rating of not less than the required rating of the floor or wall penetrated. Where sleeves are required, the sleeve size shall be installed with the inside clear diameter providing clearances as required below. Coordinate the required opening sizes with the manufacturer of the fire protection products.
1. Uninsulated pipe penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each uninsulated pipe.
2. Insulated pipes penetrations through non-rated walls and floors: pipe penetration sizes shall be a 1” (minimum) to 2” (maximum) larger than the outside diameter of each pipe, including insulation.
3. Uninsulated pipe penetrations through fire rated walls and floors, and through roof: penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each uninsulated pipe to provide minimum 1/4” annular space between the outside of the pipe surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
4. Insulated pipe penetrations through fire rated walls and floors, and through roof: pipe penetration sizes shall be a 1/2” (minimum) to 1-1/2” (maximum) larger than the outside diameter of each insulated pipe to provide minimum 1/4” annular space between the outside of the insulation surface and assembly. Coordinate with specific manufacturer requirements and UL listing.
5. Uninsulated pipe penetrations through foundation and basement walls: penetration sizes shall be larger than the outside diameter of each uninsulated pipe to allow adequate space for installation of mechanical link seals. Coordinate with specific manufacturer requirements.
3.6 EQUIPMENT RAILS AND PIPE PORTALS

A. Install per manufacturer's instructions.

B. Coordinate with other trades so units are installed when roofing is being installed, as applicable.

C. Verify roof insulation thickness and adjust height of perimeter cant strips to accommodate insulation and roofing material installation.

3.7 ELECTRICAL COORDINATION

A. Division 23 installers shall coordinate with Division 26 work to provide complete systems as required to operate all mechanical devices installed under this Division of work.

B. Installation of Electrical Connections: Furnish, install, and wire (except as may be otherwise indicated) all heating, ventilating, air conditioning, etc., motors and controls in accordance with the drawings and in accordance with equipment manufacturer's written instructions and with recognized industry practices, and complying with applicable requirements of UL, NEC, and NECA's "Standard of Installation" to ensure that products fulfill requirements.

C. Division 23 has responsibilities for electrically powered mechanical equipment which is specified in Division 23 Specifications or scheduled on Division 23 Drawings as follows:
   1. Motors: Furnish and install all motors necessary for mechanical equipment.
   2. Magnetic Starters: Furnish all magnetic starters whether manually or automatically controlled which are necessary for mechanical equipment. Furnish these starters with all control relays or transformers necessary to interface with mechanical controls. If the starter is factory installed on a piece of Division 23 equipment, also furnish and install the power wiring between starter and motor.
   3. Variable Frequency Drives: Provide all VFD's associated with mechanical equipment. If the drive is installed on a piece of factory assembled equipment the wiring between motor and drive is to be provided as part of the factory equipment.
   4. Disconnects: Provide the disconnects which are part of factory wired Division 23 equipment. Factory wiring to include wiring between motor and disconnect or combination starter/disconnect.
   5. Controls: Division 23 Contractor (including the Building Automation System (BAS) Controls subcontractor) is responsible for furnishing the following equipment in its entirety. This equipment includes but is not limited to the following:
      a. Additional control panels beyond what is identified on drawings shall be provided by BAS contractor in order to provide a complete control system at no additional cost to Owner.
      b. Control relays necessary for controlling Division 23 equipment.
      c. Control transformers necessary for providing power to controls for Division 23 equipment.
      d. Line voltage thermostats.
      e. Low or non-load voltage control components.
      f. Remote bulb thermostats.
      g. Non-life safety related valve or damper actuators.
      h. Float switches.
      i. Solenoid valves.
      j. Switches.
      k. Refrigeration controls.
      l. Communications wiring and conduit between control devices and mechanical equipment. Control wiring gauge in stranded or solid wire configuration shall be the
responsibility of the contractor to coordinate with manufacturers for allowable lengths and load requirements to assure complete and operational systems.
m. Raceway to support control cabling.

6. Fire/Smoke Dampers: Division 23 is responsible for providing and physically installing the damper and for installing any required control interface wiring to Division 23 controls.
   a. Where fire/smoke dampers are part of an integrated smoke control system, Division 23 is responsible for providing dampers with necessary end switches for use by Division 28 in providing proof of closure.
   b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed in ductwork by Division 23 but wired to the damper controller by Division 26.

D. Division 26 Electrical Responsibilities:
   1. BAS Controls Contractor shall initiate and coordinate a meeting with the Electrical Contractor and General Contractor to coordinate all BAS component locations and wiring requirements prior to start of construction. All additional costs associated with lack a coordinated shall be the responsibility of the BAS Contractor at no additional cost to the Owner.
   2. Additional power requirements, including conduit and wiring, for additional or relocated control panels and devices shall be coordinated and the responsibility of the BAS Controls Contractor at no additional cost to Owner.
   3. Motors: Provide the power wiring for the motors from servicing panel to motor controller.
   4. Magnetic Starters: Except where magnetic starters are factory installed on Division 23 factory assembled equipment, Division 26 is to install magnetic starters furnished by Division 23 and install the necessary power wiring to the starter and from the starter to the motor. In the case of factory installed starters, Division 26 is to install the necessary power wiring from source panel/disconnect to the starter.
   5. Variable Frequency Drives: Provide the necessary power wiring to the VFD and from the VFD to the motor except in the case of factory installed VFD’s where wiring between the motor and VFD is to be by Division 23.
   6. Disconnects: Provide all disconnects necessary for Division 23 mechanical equipment which are not provided as part of factory wired Division 23 equipment. Provide power wiring to all disconnects. In addition, provide power wiring between motor and disconnect when the disconnect is not factory installed.
   7. Controls: Division 26 is responsible for providing power to mechanical control panels and provide final power connection to Division 23 provided control transformers.
   8. Fire/Smoke Dampers: Division 26 is responsible for power wiring to each damper and as follows:
      a. Where these dampers are part of an integrated smoke control system Division 28 is responsible for providing the detectors and for all fire/smoke detection system wiring necessary to integrate dampers and related end switches into the system.
      b. Where these dampers are not part of an integrated area wide smoke detection system, Division 23 is responsible for providing each fire/smoke damper with a dedicated duct smoke detector installed per the requirements of the building code. If not integral with the damper assembly, the detector is to be installed by Division 23, but wired for damper control by Division 26.

E. Motors and Motor Control Equipment: Conform to the standards of the NEMA. Equip motors with magnetic or manual line starters with overload protection. Motor starters and line voltage controls shall be installed under Electrical Section but located and coordinated as required under this Section of the work. Starters shall be combination type with non-fusible disconnect
switches. All single phase fractional horsepower motors shall have built-in overload protection.

3.8 FIELD PAINTING

A. All painting shall be provided under this Division work, unless otherwise specified under Section 099100: Painting. Painting schemes shall comply with ANSI A13.1. Paint all exposed materials such as piping, ductwork, equipment, insulation, steel, etc. The inside surface of visible ductwork above diffusers/grilles shall be painted flat black.

B. All exposed work under Division 23 shall receive either a factory finish or a field prime coat finish, except:
   1. Exposed copper piping.
   2. Aluminum jacketed outdoor insulated piping.

3.9 FACTORY PAINTING

A. Manufacturer's standard factory painting systems may be provided subject to certification that the factory painting system applied will withstand 125 hours in a salt-spray fog test, except that equipment located outdoors must withstand 500 hours in a salt-spray fog test. Salt-spray fog test must be in accordance with ASTM B117, and for that test the acceptance criteria must be as follows: immediately after completion of the test, the paint must show no signs of blistering, wrinkling, or cracking, and no loss of adhesion; and the specimen must show no signs of rust creepage beyond 3 mm 0.125 inch on either side of the scratch mark. The film thickness of the factory painting system applied on the equipment must not be less than the film thickness used on the test specimen. If manufacturer's standard factory painting system is being proposed for use on surfaces subject to temperatures above 120°F (50°C), the factory painting system must be designed for the temperature service.

3.10 IDENTIFICATION MARKERS

A. General: Where identification is to be applied to surfaces which require insulation, painting, or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping System Identification:
   1. Install pipe markers on each system indicated to receive identification, and include arrows to show normal direction of flow.
   2. Locate pipe markers as follows:
      a. Near each valve and control device.
      b. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
      c. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible enclosures.
      d. At access doors, manholes, and similar access points which permit view of concealed piping.
      e. Near major equipment items and other points of origination and termination.
      f. Spaced horizontally at maximum spacing of 20' along each piping run, with minimum of one in each room.
      g. Vertically spaced at each story transversed.

C. Ductwork Identification: A minimum of every 50' for all ductwork, 12" or more in diameter or width, where ducts are concealed above accessible ceilings.
D. Mechanical Equipment Identification: Locate engraved plastic laminate signs on or near each major item of mechanical equipment and each operational device. Provide signs for the following:
1. Main control and operating valves, including safety devices.
2. Meters, gauges, thermometers, and similar units.
3. Pumps.
4. Chillers.
5. Boilers.
6. Fans.
7. Compressors and similar motor-driven units.
8. Hot water system mixing valves and similar equipment.
9. Heat exchangers and similar equipment.
11. Packaged HVAC central-station and zone-type units.
12. Tanks and pressure vessels.
13. Strainers, filters, treatment systems and similar equipment.

E. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations. Equipment signs shall include an identification of the area or other equipment served by the equipment being labeled.

F. Underground Piping Identification: During backfilling/topsoiling of each exterior underground piping system, install continuous underground-type plastic line marker, located directly over buried line at 6" to 8" below finished grade. Where multiple small lines are buried in common trench and do not exceed overall width of 16", install single line marker.

3.11 VIBRATION AND DYNAMIC BALANCING

A. All equipment submitted and installed by Division 23 shall not exceed maximum tolerances as specified by the “International Research and Development Corporation”, Worthington, Ohio, measured by the displacement, peak to peak, as follows:
1. All Fans: Below severity chart labeled “FAIR”, maximum velocity of 0.0786 in/sec, peak.
2. Pump and Electric Motors: Below severity chart labeled “SLIGHTLY ROUGH”, maximum vibration velocity of 0.157 in/sec, peak.
3. Compressors: Same as pumps.

B. Where installed equipment noise or vibration is objectionable to the Owner’s Representative, it shall be responsibility of the contractor to conduct testing to confirm that the equipment does not exceed the standard.

C. Correction shall be made to all equipment, which exceeds vibration tolerances specified above. Final vibration levels shall be reported as described above.

3.12 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Upon completion of testing, certify to the Owner’s Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by qualified inspector.
B. Ductwork: Test all air quantities as specified in Section 230593 - Testing, Adjusting and Balancing. Pressure tests per SMACNA.

C. Registers and Diffusers: Test for proper operation of manually operated control feature. Test all air quantities as specified in Section 230593 – Testing, Adjusting and Balancing.

D. Ductwork Specialties: Test all operable ductwork specialties for proper operation. Check all fire, smoke and fire/smoke dampers to ensure that they are 100% open.

E. Temperature Control: Test all control functions to assure that all systems are controlling as specified or as otherwise necessary and that all controls are adjusted to maintain proper room temperatures. The manufacturer’s representative shall perform all tests.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SUMMARY

A. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the specification shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure.

B. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

C. All mechanical equipment, piping and ductwork as noted on the equipment schedule, in the specification or as required by code shall be designed to resist seismic forces. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment.

D. This Section includes the following:
   1. Vibration isolation curbs, pads and mounts.
   2. Flexible ductwork connectors.
   4. Spring isolators.
   5. Restrained uni-directional seismic isolation snubber mounts.
   6. Housed seismic spring vibration mounts.
   7. Elastomeric hangers.
   8. Pipe riser resilient supports.
   9. Resilient pipe guides.
  10. Air-mounting system.
  12. Seismic snubbers.
  13. Vibration isolation equipment bases.
  14. Flexible piping connectors.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230549: Seismic Restraint for Piping, Ductwork and Equipment.

1.4 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. FRT: Fire retardant treated wood is any wood product that, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E84 or UL 723, a listed flame spread index of 25 or less.


1.5 CODES AND STANDARDS

A. Provide components conforming to the load requirements of the latest addition of the local building code and the following:
   1. International Building Code with AHJ Amendments
   2. American Society of Civil Engineers (ASCE):
   3. The Manufacturers Standardization Society (MSS):
      b. MSS SP-69: Pipe Hangers and Supports - Selection and Application.
      c. MSS SP-89: Pipe Hangers and Supports - Fabrication and Installation Practices.
      a. For all suspended piping, suspended ductwork and suspended electrical raceways.

1.6 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Refer to Section 230549 Seismic Restraint for Piping, Ductwork and Equipment for seismic specific requirements.
   2. Vibration isolators must be rated for the seismic loading associated with the system and forces calculated for this building location. Seismic forces for new installations are determined per ASCE 7. Refer to Structural Design for seismic factors and design criteria. Select and submit appropriate values for each piece of equipment and subsystem and material type for the project, and base the seismic calculations on these values.
   3. Coordinate all seismic and load requirements with the registered professional Structural Engineer.

B. Component Importance Factor:
   1. Ip=1.0: Standard Occupancies and components associated with Risk Category I, II, and III, including offices and schools.

1.7 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Building Structural Limits: The design of supports and restraints shall not exceed the building structure allowable point loads. Coordinate all work with the registered professional Structural Engineer.

D. Special Inspections: Provide structural design and Special Inspections as required by Chapter 17 of the IBC, the Authority Having Jurisdiction, and as defined in the manufacturer installation instructions for each anchorage system. Per IBC Section 1705 all anchors post-installed in hardened concrete members shall have periodic Special Inspections. Special inspection
agencies shall be independent of the design and construction companies and shall act as agents for the AHJ, but contracted directly with the Owner or Owner’s Representative.

1.8 WARRANTY

A. Provide minimum one-year warranty requirements, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

1.9 SUBMITTALS

A. Product Data shall include the following:
   1. Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the specification.
   2. Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive drawings.
   3. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   4. 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 evaluation service or agency acceptable to authorities having jurisdiction.
      b. Annotate to indicate application of each product submitted and compliance with requirements.
   5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:
   1. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.
   2. Provide all details of suspension and support for ceiling hung equipment.
   3. Where walls, floors, slabs or supplementary steel work are used for seismic restraint the locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers’ submittals must include spacing, static loads and seismic loads at all attachment and support points.
   4. Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

C. Manufacturer Design Submittal: For vibration isolation details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and where required wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
   2. 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 that riser system has been examined for excessive stress and that none will exist.
   3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component
misalignment, and cantilever loads. Provide base with level top surfaces with integral sloping on bottom to match support structure.

D. Coordination Drawings: Show coordination and plan locations of vibration isolation for HVAC ductwork, piping, and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

E. Qualification Data: Devices shall be selected to meet seismic and support requirements by a registered professional Structural Engineer.

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent test agency.

G. Operation and Maintenance Data: For air-mouting systems to include in operation and maintenance manuals.

1.10 WARRANTY

A. Refer to section 230500 for basic warranty requirements.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS AND APPLICATION

A. Factory Finishes:
   1. Standard paint applied to factory-assembled equipment before shipping.
   2. Powder coating on springs and housings.
   3. All hardware shall be galvanized or powder coated.
   4. Hot-dip galvanized or powder coating of metal components for exterior use.
   5. Baked enamel or powder coat for metal components for interior use.

B. Glumac Device Key Schedule: Part 3 of this Section schedules the application of devices described in Part 2 for use with mechanical equipment found on this project. The tag designation of preferred devices is as follows:

<table>
<thead>
<tr>
<th>Glumac Isolator Tag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-1</td>
<td>Spring and rubber in shear vibration isolation hanger</td>
</tr>
<tr>
<td>SB-1</td>
<td>Sway bracing</td>
</tr>
<tr>
<td>F-2</td>
<td>Stainless hose flexible piping coupling</td>
</tr>
<tr>
<td>F-4</td>
<td>Flexible ductwork connector</td>
</tr>
</tbody>
</table>

2.2 SPRING HANGERS

A. H-1 Style: Spring hangers shall consist of rigid steel frames containing minimum 1-1/4” (32 mm) thick neoprene elements at the top and steel springs that are free standing and laterally stable seated in a steel washer reinforced neoprene cup at the bottom. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The neoprene element and the cup shall have a neoprene bushing projecting through the steel box. A seismic rebound washer made of steel and surrounding neoprene shall be provided. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Manufacturers: Mason #RW30N Series or equal.
2.3 PIPE GUIDES AND SUPPORTS

A. G-1 Style: All-directional acoustical pipe anchors shall consist of two sizes of steel tubing separated by a minimum 1/2" (12 mm) thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. Manufacturers: Mason #ADA Series or equal.

B. G-2 Style: Vertical sliding pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" (20 mm) thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of 1-5/8" (41 mm) upwards or downwards motion, or to meet location requirements. Manufacturers: Mason #VSG Series or equal.

C. G-3 Style: Horizontal thrust restraints shall consist of a spring element seated in a steel washer reinforced neoprene cup at the bottom, in series with a molded neoprene element. Steel springs shall be free standing and laterally stable. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4" (6 mm) movement at start and stop. The assembly shall be furnished with 1 rod and angle brackets for attachment to both the equipment and the ductwork or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Manufacturers: Mason #WBI Series or #WBD Series or equal.

2.4 SWAY BRACING

A. SB-1 Style: Seismic sway braces shall consist of galvanized steel aircraft cables or steel angles or struts. Cables braces shall be designed to resist seismic tension loads and steel braces shall be designed to resist both tension and compression loads with a minimum safety factor of two (2). Brace end connections shall be steel assemblies that swivel to the final installation angle. Steel angles or struts, when required, shall be clamped to the threaded hanger rods at the seismic sway brace locations utilizing a minimum of two ductile iron clamps. Do not mix cable and steel braces to brace the same system or equipment. Manufacturers: Mason #SCB Series or #SCBH Series, steel brace assemblies shall be Mason #SSB Series, #SSBS Series or #SHB Series, and rod clamps shall be Mason #SRC Series or #UCC Series or equal.

2.5 FLEXIBLE PIPING CONNECTORS

A. F-2 Style: Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings.
   1. Sizes 1/2" (15 mm) to 2" (50 mm):
      a. EPDM or Kevlar core hose with stainless steel braid and brass end fittings. Swivel union ends for threaded nipples or copper sweat ends. Minimum 175 psig working pressure rating. Operating temperature range from 32°F to 225°F (0°C to 107°C). Hoses must have sufficient length, minimum 12" (300 mm) long, to accept 1/2" (12 mm) intermittent motion without failure. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Manufacturers: IMI #Versaflow, Nexus #UF Series, Pro Hydronic Specialties, Titus, Victaulic, Hays Fluid Control, or equal.
2. Sizes 2-1/2” (65 mm) and larger:  
   a. EPDM, Kevlar or corrugated stainless-steel core hose with stainless-steel braid.  
      Threaded, flanged or brazed weld ends. Minimum 200 psig working pressure rating.  
      Operating temperature range from 32°F to 225°F (0°C to 107°C). Manufacturers:  
      Mason #FFL Flanged, #CPSB Copper, #CSAMN Threaded, or equal.

2.6 FLEXIBLE DUCTWORK CONNECTORS

A. F-4 Style: Flexible ductwork connection fabricated of fiberglass canvas with fire resistant rated neoprene and UV resistant coating. Stainless steel metal edge banding.

B. Flexible Connections (Indoor Applications):  
   1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.  
   2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.  
   3. Shall be airtight, watertight and fire retardant.  
   4. Minimum density of 30 oz. per sq. yard.  
   5. Temperature range: -40°F to 200°F  
   6. Neoprene-only connectors are not allowed.  
   7. Minimum dimensions shall be 3” metal, 3” fabric, 3” metal.  
   8. Manufacturers: Ventfabrics #Ventglas or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.

C. Flexible Connections (Outdoor Applications):  
   1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.  
   2. Hypalon (chlorosulfurated polyethylene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame.  
   3. Shall be airtight, watertight and fire retardant. Resistant to sunlight, ozone and weather.  
   4. Minimum density of 26 oz. per sq. yard.  
   5. Temperature range: -50°F to 275°F  
   6. Surface-Burning Characteristics: Non-combustible as tested per UL 701. Or, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723/ASTM E84.  
   7. Minimum dimensions shall be 3” metal, 3” fabric, 3” metal.  
   8. Provide flexible cloth insulating blanket to encase flexible connections to maintain ductwork insulation integrity as follows:  
      a. Jacket shall be UV and ozone resistant with Velcro attachment.  
      b. Service Operating Temperature: 0-350°F.  
      c. Jacket and Liner: silicon or teflon impregnated fiberglass or mineral wool cloth.  
      d. Insulation: Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.  
      e. Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings.  
      g. Manufacturers: Thermal Energy Products, Coverflex, Thermaxx, Pacor, Unitherm, Advance Thermal, Fit Tight Covers, or equal.  
   9. Manufacturers: Ventfabrics #Ventlon or approved equal by Duro Dyne, Q Industries, consolidated Kinetics, Ductmate Proflex or Elgen.
2.7 BRACING DEVICES FOR EQUIPMENT, PIPING, AND DUCTWORK

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Amber/Booth Company (VMC Group)
   2. California Dynamics Corporation
   3. Cooper B-Line, Inc.
   4. Hilti, Inc.
   5. Kinetics Noise Control
   7. Mason Industries
   8. Tolco Incorporated
   9. Unistrut
   10. ISAT, Inc
   12. VMC Group

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least two (2) times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4" (6 mm) thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with 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; and rated in tension, compression, and torsion forces.

E. Hanger Rod Stiffener: Steel tube, steel slotted support system sleeve or reinforcing steel angle clamped to hanger rod are acceptable.

F. Bushings for Floor-Mounted Equipment Anchorage: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

G. 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.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. 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 E488. Minimum length of eight times diameter.
J. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 EXECUTION

3.1 LOCATION AND APPLICATION OF VIBRATION ISOLATION EQUIPMENT

A. The following Tables provide schedules for minimum vibration devices required for isolation of mechanical equipment provided on the project. Refer to Part 2 above for device specifications. Coordinate with additional requirements recommended by device manufacturers. Sizes show below take precedent as the minimum requirements. Use the greater of the sizes shown as follows or shown on the drawings.

B. Air Handling Units Equipment Isolation:

<table>
<thead>
<tr>
<th>TABLE 1: EQUIPMENT ISOLATION SCHEDULE – Fans &amp; Fan Power Boxes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQUIPMENT TYPE</strong></td>
</tr>
<tr>
<td><strong>ISOLATOR TYPE</strong></td>
</tr>
<tr>
<td>SUSPENDED (4)</td>
</tr>
<tr>
<td>Up to 15 HP</td>
</tr>
</tbody>
</table>

Notes:
(1) Alternate: Factory installed by equipment manufacturer factory installed.
(2) Provide full perimeter steel welded frame below equipment
(3) Provide support per manufacturer’s recommendation
(4) For pipe and duct connections provide F-2 pipe and F-4 duct connectors.
(5) Span is the beam or girder distance between columns or exterior fixed wall supports.

3.2 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service or agency acceptable to authorities having jurisdiction. Indicate on Drawings, by details, schedules, or a combination of both, the locations where hanger rods for individual pipes and hanger rods for trapeze hangers require hanger rod stiffeners.
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 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.

3.4 VIBRATION-CONTROL DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Comply with manufacturer's recommendations for selection and application of vibration isolation materials and units except as otherwise indicated. Comply with minimum static deflections recommended by ASHRAE, of vibration isolation materials and units where not otherwise indicated.

C. Comply with manufacturer's instructions for installation and load application to vibration control materials and units except as otherwise indicated. Adjust to ensure that units have equal deflection, do not bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices intended for temporary support during installation.

D. All vibration isolator systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

E. Installation of vibration isolators must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

G. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the attention of the Owner's Representative prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

H. Install units between substrate and equipment as required for secure operation and to prevent displacement by normal forces, and as indicated.

I. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where substrate is not level.

J. Flexible Pipe Connectors: Install on equipment side of shutoff valves.

K. Upon completion of vibration control work, prepare report showing measured equipment deflections for each major item of equipment as indicated. Clean each vibration control unit, and verify that each is working freely, and that there is no dirt or debris in immediate vicinity of unit that could possibly short-circuit unit isolation.

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

N. 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.

O. 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 pre-stressed 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.

3.5 VIBRATION ISOLATION OF PIPING

A. Horizontal Piping: The first three pipe supports from vibration isolated equipment must be vibration isolated to minimize fluid transmitted vibration. The static deflection of the pipe support isolators must be equal to the static deflection for the isolators supporting the connected equipment. Overhead piping shall suspend from Mason Type 30N spring hangers or equal. Floor supported piping shall rest on Mason Type SLR isolators or equal. Refer to contract drawings for additional vibration isolation requirements for piping. Where piping connects to mechanical equipment install Mason Type SFDEJ or SFU expansion joints or Mason Type FFL stainless hoses if Type SFDEJ or SFU is not suitable for the service.

B. Riser isolation: Risers that experience excessive thermal expansion shall be suspended from Mason Type 30N spring hangers or supported by Mason Type SLF(H) spring mountings, anchored with Mason Type ADA(H) anchors, and guided with Mason Type VSG(H) sliding guides. Horizontal pipe runs and branches shall be supported on Mason Type 30N spring hangers for the first three supports from the risers. Steel springs shall be selected to provide a minimum of 0.75" static deflection except in those expansion locations where additional deflection is required to limit load changes to + 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

3.6 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, 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.
3.7 ADJUSTING

A. Adjust isolators after piping 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.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.8 AIR MOUNTING SYSTEM DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 WORK RELATED IN OTHER SECTIONS

A. Section 230500: Basic HVAC Materials and Methods.

B. Section 230900: Building Automation System (BAS) Controls.

C. Section 232113: Hydronic Piping, Valves and Specialties.

D. Section 233113: Air Distribution.

E. Division 26: Electrical.

1.3 SUMMARY

A. Scope: Extent of testing, adjusting and balancing work required by this Section is indicated on the drawings, in schedules, and by the requirements of this Section, and Section 230500 - Basic Mechanical Requirements.

B. Systems: Testing, adjusting and balancing specified in this Section shall include, but not be limited to, the following systems:
   1. Air handling systems including supply, return and exhaust.
   2. Air distribution ductwork including supply, return and exhaust.
   3. Dedicated exhaust systems.
   4. Building automation system controls.
   5. Hydronic system including heating and chilled water
   6. Instruction of Owner's personnel for future balancing of systems.

1.4 CODES AND STANDARDS

A. The Contractor is cautioned that code requirements not explicitly detailed in these specifications or drawings, but which may be reasonably inferred or implied from the nature of the project, must be provided as part of the contract.

B. Reference Standards
   4. AABC - National Standards for Total System Balance.
   5. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.
8. ANSI - American National Standards Institute. Comply with the following:
   a. S1.4: Specifications for Sound Level Meters.
   b. S1.11: Specifications for Electroacoustics - Octave-Band and Fractional-Octave-Band Filters
10. Mechanical Code, with State Amendments, Chapter 4 Ventilation Air Supply.

1.5 QUALITY ASSURANCE

A. Contractor’s Qualifications: A specialist certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) with at least 5 years of experience in those testing, adjusting and balancing requirements similar to those required for this project, is not the installer of the system to be tested and is otherwise independent of the project. Testing, adjusting, and balancing shall be performed by a certified NEBB technician or a certified AABC technician under direct field supervision of a Certified NEBB Supervisor or a Certified AABC Supervisor. Testing and balancing agency must submit qualifications for review and approval prior to acceptance for work.

B. Penalty: The Contractor shall submit the name of the organization he proposes to employ for approval within 30 days after contract award. If the Contractor fails to submit the name of an acceptable agency within the specified time, a firm may be selected to accomplish the work, and this selection shall be binding upon the Contractor at no additional cost.

C. Retainages: In addition to any other sums retained or withheld pursuant to the provisions of this Contract, the amount of dollars will be withheld from payments to the contractor until such time as the work has been completed and accepted. In no event will this amount be paid to the Contractor prior to 60 days following acceptance of the project; during such time, the Contractor shall investigate and correct any reported deficiencies unless such deficiencies are a result of unauthorized tampering by building occupants.

D. Calibration of Testing Instruments: All measurement instruments used for testing, adjusting, balancing, and commissioning shall be calibrated. The time between the most recent calibration data and the final test report date shall not be over 6 months.

E. Testing and balancing agency, as part of its contract, shall act as authorized inspection agency responsible to Consulting Engineer and Owner, and shall list all items that are installed incorrectly, require correction, or have not been installed in accordance with contract Drawings and Specifications, pertaining to air distribution, cooling and heating systems. The testing and balancing agency is required to provide written reports of all deficiencies and proposed recommendations to the Owner’s Representative, Contractor, Architect and Engineer.

F. The testing and balancing agency shall provide with their bid a performance guarantee covering all phases of the work as herein specified.

G. The General and Mechanical Contractors shall cooperate with the selected testing and balancing agency in the following manner:
   1. Provide sufficient time before final completion dates so that tests and balancing can be accomplished.
   2. The various system installers, suppliers and contractors shall provide all required materials, labor and tools to make corrections when required without undue delay. Install balancing dampers and valves as required by testing and balancing agency.
3. The contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of the same during each working day of testing and balancing.

4. Testing and balancing agency shall be kept informed of any major changes made to the system during construction, and shall be provided with a complete set of Record Drawings.

5. The General Contractor shall make space and other facilities available to the testing and balancing agency to enable their work to progress. The General Contractor shall schedule the work of other trades to avoid conflicts with this work.

H. All air balancing work shall be coordinated with other disciplines to comply with the meet or exceed the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, local amendments and State Energy Code.

1.6 SUBMITTALS

A. Conform to the Submittals requirements of Division 01.

B. Forms: The Contractor shall deliver a complete copy of either NEBB or AABC standard forms for testing and balancing work associated with the project. These forms shall serve as specific guidelines for producing final test report. Hybrid or non-standards forms are not acceptable.

C. Test Reports: Provide six (6) certified test reports, signed by the test and balance supervisor who performed the work. The final reports shall include key plans identifying all inlets and outlets. Final test reports shall be typed. Handwritten reports are not acceptable.

D. Maintenance Data: Include, in maintenance manuals, copies of certified and approved test and balance reports and identification of instruments.

E. Qualifications: The Test and Balance Agency shall submit qualifications of all persons responsible for supervising and performing the on-site testing and balancing work and the name of the certifying agency, NEBB or AABC. Provide a reference list of five (5) similar size projects with contact person and telephone number.

F. LEED:
   1. Air-Balance Report for Prerequisite EQp1: Documentation of work performed per ASHRAE 2.1, Section 7.2.2 - "Air Balancing".
   2. TAB Report for Prerequisite EAc2: Documentation of work performed per ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing".

1.7 AGENDA

A. Agenda: A preliminary report and agenda shall be submitted and approved prior to the start of testing and balancing work.
   1. Review plans and specifications prior to installation of any of the affected systems, and submit a report indicating any deficiencies in the systems that would preclude the proper adjusting, balancing, and testing of the systems.
   2. The agenda shall include a general description of each air and water system with its associated equipment and operation cycles for heating and cooling.
   3. The agenda shall include a list of all air and water flows to be performed at all mechanical equipment.
   4. The agenda shall incorporate the proposed selection points for sound measurements, including typical spaces as well as sound sensitive areas such as conference rooms.
5. The agenda shall also include specific test procedures and parameters for determining specified quantities (e.g. flow, drafts, sound levels) from the actual field measurements to establish compliance with contract requirements. Samples of forms showing application of procedures and calculations to typical systems shall be submitted.

6. Specific test procedures for measuring air quantities at terminals shall specify type of instrument to be used, method of instrument application (by sketch) and factors for:
   a. Air terminal configuration.
   b. Flow direction (supply or exhaust).
   c. Velocity corrections.
   d. Effective area applicable to each size and type of air terminal.
   e. Density corrections.

7. The agenda shall include identification and types of measurement instruments to be used, and their most recent calibration date.

1.8 JOB CONDITIONS

A. General: Do not proceed with testing, adjusting and balancing work until the following conditions have been met.
   1. Installation and start-up work on equipment or systems to be tested has been completed and documented.
   2. Work area scheduled for testing, adjusting and balancing is clean and free from debris, dirt and discarded building materials.
   3. All architectural openings (doors, windows, and other openings) which may affect the operation of the system to be tested shall be in their completed normal positions and operation.
   4. All related mechanical systems which may affect the operation of the system to be tested shall be at their normal operating conditions.

PART 2 PRODUCTS

2.1 TEST HOLES

A. Test holes and ports shall be provided in ducts, housings and pipes as directed by the Balancing Agency. At each location where ducts or plenums are insulated, test holes shall be provided with an approved extension with plug fitting.

2.2 PATCHING MATERIALS

A. Material: Seal, patch and repair ductwork, piping and equipment drilled or cut for testing purposes.
   1. Plastic plugs with retainers may be used to patch drilled holes in ductwork and housings.
   2. Insulation shall be neatly hemmed with metal or plastic edging, leaving test points visible for future testing.

2.3 TEST INSTRUMENTS

A. Test Instruments: All instruments used for measurements shall be accurate and calibration histories for each instrument shall be available for examination. Each test instrument shall be calibrated by an approved laboratory or by the manufacturer. The Owner’s Representative has the right to request instrument recalibration, or the use of other instruments and test methodology, where accuracy of readings is questionable.
B. Additional Instruments: Permanently installed measuring instruments, such as temperature and pressure gauges, shall be checked against Certified Calibrated instruments. Any instrument which does not meet specification requirement shall be replaced or recalibrated.

C. Cone Instruments: The Contractor shall employ manufactured enclosure type cones, capable of air volume direct readings, for all diffuser/grille/register air flow measurements. The readout meters shall meet calibration requirements.

PART 3 EXECUTION

3.1 PROCEDURES AND INSTRUMENTS, GENERAL

A. Requirements: All systems and components thereof shall be adjusted to perform as required by approved project drawings and specifications.

B. Test Duration: Operating tests of heating and cooling coils, fans, and other equipment shall be of not less than four-hours duration after stabilized operating conditions have been established. Capacities shall be based on temperatures and air and water quantities measured during such tests.

C. Instrumentation: Method of application of instrumentation shall be in accordance with the approved agenda.
   1. All instruments shall be applied in accordance with the manufacturer's certified instructions.
   2. All labor, instruments, and appliances required shall be furnished by the Contractor. Permanently installed instruments used for the tests (e.g., flow meters and Btu meters) shall not be installed until the entire system has been cleaned and ready for operation.

3.2 DUCT SMOKE DETECTORS

A. Duct smoke detectors shall be provided and located as required by these specifications and drawings and as required by the building codes and the following:
   1. Obtain information from the Contractor who is to furnish the smoke detectors on the proper device placement and installation limitations and on the proper differential pressure across the sampling tubes of the duct detectors and for required air velocity range requirements.
   2. Installing Contractor shall review the manufacturer's installation guidelines for proper mounting locations.
   3. The testing and balancing agency shall be engaged to confirm that proposed mounting locations will not be adversely impacted by airflows.

B. Duct smoke detectors shall be tested in collaboration with the installing Contractor and project Fire Alarm Contractor to ensure proper air flow sampling and differential pressure.

3.3 DUCTWORK AIR LEAKAGE TESTING

A. Dust leakage testing is required on all ductwork constructed to 4” wg class and higher.

B. Test and balance agency shall perform active air flow testing of ductwork systems or sections of ductworks. Agency shall inspect and confirm that all ductwork is sealed per the specification requirements prior to performing any testing. Calculate maximum allowable air leakage by system based on total design air flow rate and/or square footage of ductwork. Maximum allowable system air flow leakage shall not exceed 5% of total air volume, or the
maximum allowable per local energy or mechanical codes where the allowable limit is less than 5%.

C. Representative sections totaling 10 percent, or greater, of the total installed duct area shall be tested. Where the tested 10 percent fails to comply with the requirements, then 40 percent of the total installed duct area shall be tested. Where the tested 40 percent fails to comply then 100 percent of the total installed duct area shall be tested and verified to have a leakage rate that does not exceed the maximum allowable limit. Duct sections shall be selected by the Owner's Representative. Obtain total duct surface area and air flow volumes for each duct section from the installing contractor. Positive pressure leakage testing shall be permitted for negative pressure ductwork.

D. Additional ductwork leakage testing may be required to meet local energy and mechanical code requirements. Refer to local codes for applicability and requirements.

E. Ductwork systems to be leakage tested and procedures shall include:
   1. Testing shall be performed at 1.5 times the peak design outlet static pressure (external static pressure) from the air handling unit/fan, but not greater than the maximum SMACNA pressure rating of the ductwork construction classification.
   2. Testing is not required of flexible ductwork or ductwork downstream of VAV terminal units.
   3. Leakage through manufactured products, such as air handling units, dampers, fire/smoke dampers and terminal units may be excluded from the leakage calculations based on manufacturer stated values, at pressure, or these units may be temporarily sealed with painter's tape or plastic sheeting during testing to seal any openings and must be removed after testing.
   4. Supply air ductwork from the outlet of the air handling unit/fan to inlet side of terminal units or connection to flexible ductwork. Duct leakage testing is not required downstream of terminal units.
   5. All supply, return and exhaust air ductwork located outside the building envelope.
   6. Return and exhaust air ductwork located in unconditioned spaces from inlet of the air handling unit/fan to the ductwork terminations upstream of each return air grille.
   7. Laboratory and fume hood exhaust air ductwork from inlet of the air handling unit/fan to the connection at the remote exhaust air grille or fume hood connection.
   8. Kitchen exhaust air ductwork from inlet of the exhaust fan to the connection at the remote exhaust hood.

F. For buildings under the jurisdiction of the UMC or CMC provide duct leakage testing in compliance with maximum allowable leakage quantities per code Section 603 and in no case greater than 5% of the total system air flow volume. Ductwork shall be leak-tested in accordance with the procedures described in SMACNA HVAC Air Duct Leakage Test Manual. The permitted duct leakage shall be not more than the following:
   1. \( L_{\text{MAX}} = C_L P^{0.65} \)
      a. \( L_{\text{MAX}} \)=maximum permitted leakage \((\text{ft}^3/\text{min}/100 \text{ sf} [0.0001 \ (\text{m}^3/\text{s})/\text{m}^2])\) duct surface area.
      b. \( C_L \)=Six (6), SMACNA duct leakage class \((\text{ft}^3/\text{min}/100 \text{ sf} [0.0001 \ (\text{m}^3/\text{s})/\text{m}^2])\) duct surface area at 1 inch water column (0.2 kPa).
      c. \( P \)=test pressure, which shall be equal to the design duct pressure class rating in inches of water column (kPa).

G. Additional leakage testing in California, per the energy code, requires that duct systems shall be sealed to a leakage rate not to exceed 6% of the fan flow if the duct systems are:
   1. Connect to a constant volume, single zone system, air conditioners, heat pumps or furnaces, and,
2. Serve less than 5,000 square feet of floor area, and
3. Have more than 25% duct surface area located in one or more of the following places:
   a. Outdoors, or,
   b. In a space directly under a floor where the U-factor of the roof is greater than the U-factor of the ceiling, or,
   c. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces, or,
   d. In an unconditioned crawlspace, or,
   e. In other unconditioned spaces.

H. Ductwork installer shall prepare ductwork for pressure testing as deemed appropriate to maintain construction schedule. Ductwork may be tested as total systems or in sections. Sectional testing will require documentation to prove the totalized system leakage is within allowable range of entire system. Ductwork inlets and outlets may be temporarily sealed airtight with plastic, or other means, to facilitate testing pressures.

I. Testing may occur through ductwork devices such as balancing dampers, smoke fire dampers and coils. Manufacturer provided air leakage allowances for such devices may be excluded from duct leakage measurement but must be documented in final report.

J. The leakage rate shall be confirmed through field verification and diagnostic testing in accordance with procedures defined by Oriflow Air Leakage Test, or equivalent procedure. Perform all testing utilizing a duct leakage testing system, Oriflow Duct Leakage Tester or equal, with calibrated fan, orifice, gauges, ductwork, pressure tips and tubing.

3.4 AIR SYSTEM PROCEDURES

A. Adjustments: Adjust all air handling systems to provide design air quantity to or through, each component, and to maintain stable and comfortable interior temperatures, free of drafts or stagnant air conditions.

B. Equalizers: Equalizing devices shall be adjusted to provide uniform velocity across the inlets (duct side for supply) of terminals prior to measuring flow rates.

C. Balance: Flow adjusting (volume control) devices shall be used to balance air quantities (i.e., proportion flow between various terminals comprising system) to the extent that their adjustments do not create objectionable air motion or sound (i.e., in excess of specified limits).
   1. Balancing between runs (sub mains, branch mains, and branches) generally shall be accomplished by flow regulating devices at, or in, the divided-flow fitting.
   2. Restriction imposed by flow regulating devices in or at terminals shall be minimal.
   3. Final measurements of air quality shall be made after the air terminal has been adjusted to provide the optimum air pattern of diffusion and as indicated on the air distribution drawings.

D. Fan Adjustment: Total air system quantities, generally, shall be varied by adjustment of fan speeds or axial-flow fan wheel blade pitch. Damper restriction of a system’s total flow may be used only for systems with direct-connected fans (without adjustable pitch blades), provided system pressure is less than 0.5” w.g. and sound level criteria are met.

E. Air Measurement: Where air quantity measuring devices are specified in other sections such systems shall be used as a cross-check of portable measuring equipment.
   1. Except as specifically indicated herein, pitot tube traverses shall be made of each duct to measure air flow therein. Pitot tubes, associated instruments, traverses, and techniques shall conform to the ASHRAE “Handbook Fundamentals Inch Pound Edition.”
2. For ducts serving modular office areas with movable partitions, which are subject to change, pitot tube traverses may be omitted provided the duct serves only a single room or space and its design volume is less than 2000 cfm. In lieu of pitot tube traverses, airflow in the duct shall be determined by totaling volume of individual terminals served, measured as described herein.

3. Where duct's design velocity and air quantity are both less than 1000 (fpm/cfm), air quantity may be determined by measurements at terminals served.

F. Test Holes: Test holes shall be in a straight duct, as far as possible downstream from elbows, bends, take-offs, and other turbulence generating devices, to optimize reliability of flow measurements.

G. Air Terminal Balancing: Generally, measurement of flow rates by means of velocity meters applied to individual terminals, with or without cones or other adapters, shall be used only for balancing. Measurement of air quantities at each type of air terminal (inlet and outlet) shall be determined by the method approved for the balancing agenda. Laboratory tests shall be conducted to prove accuracy of testing methodology and test data when so directed. Such tests shall be conducted in conformance with applicable ASHRAE or American Society of Mechanical Engineers (ASME) codes and shall be performed at no additional cost to Owner.

H. Air Motion: Air motion and distribution shall be as specified and indicated on drawings. The Contractor, at no additional cost to the Owner shall, in addition to air motion and direct measurements, perform smoke tests as requested to demonstrate the air distribution and pattern from air terminals and outlets.

I. Air system test and balance procedures shall include, but not be limited to the following requirements:
   1. Test and adjust blower RPM to design requirements.
   2. Test and record motor full load amperes.
   3. Make pitot tube traverse of main supply ducts and obtain design CFM at fans.
   4. Test and record system static pressures, suction pressure directly at system fan inlet, and outlet pressure directly at system fan outlet or discharge. Test and record static pressure across each component of air handling system (coils, filters, etc.).
   5. Test and adjust system for design CFM recirculated air.
   6. Test and adjust system for design CFM outside air.
   7. Test and record entering air temperatures.
   8. Test and record leaving air temperatures.
   9. Adjust all supply, return and exhaust air ducts to proper design CFM.
  10. Adjust all zones to proper design CFM, supply and return.
  11. Test and adjust duct systems and each diffuser, grille, and/or register to within 10% of design requirements.
  12. Each grille, diffuser and register shall be identified as to location and area.
  13. Operate each variable frequency drive (VFD) and verify controls installation is complete.
  14. Size, type and manufacturer of VAV boxes, diffusers, grilles, registers and all tested equipment shall be identified and listed. Manufacturer's ratings on all equipment shall be used to make required calculations.
  15. Readings and tests of diffusers, grilles and registers shall include required FPM velocity and test resultant velocity, required CFM and test resultant CFM after adjustment.
  16. In cooperation with the control manufacturer's representative, setting adjustments of automatically operated dampers to operate as specified, indicated, and/or noted. Testing agency shall check all controls requiring adjustment by control installers. Room thermostats shall be checked for cooling and heating response.
  17. All diffusers, grilles and registers shall be adjusted to minimize drafts in all areas.
18. Adjust overall system balances to allow all self-closing exterior doors to close from any open position. Maximum interior air pressure in all operational modes shall not exceed 0.05" static pressure relative to the outside air pressure. Comply with chapter 10 of the Building Code to assure that self-closing doors will release with a maximum force of 15 pounds.

19. As part of the work of this contract, the HVAC contractor shall make any changes in the pulleys, belts and dampers or the addition of dampers required for correct balance as recommended by air balance agency, at no additional cost to Owner.

20. After air balancing is completed and RPM determined, HVAC Contractor shall provide fixed pitch pulleys.

21. All mixing boxes, VAV air valves, control dampers, smoke dampers and similar devices which operate at 100% shut off shall be tested for leakage.

22. Variable Air Volume Fan Systems: The primary balancing mode is 100% outside air with all terminal boxes on a full call for cooling. Also check and record performance at minimum outside air with all terminal boxes on call for full cooling and at minimum outside air with all terminal boxes on call for full heating and at minimum outside air in the deadband range with no call for heating or cooling. Verify that the systems are operating on a stable part of the fan curves in each mode. Record final duct static controller settings.

23. Provide testing of underfloor air distribution plenum floor mock-ups and final floor installation to document that plenum does not exceed 5% air leakage rate at maximum 0.10” w.g. positive differential pressure.

3.5 ADA COMPLIANCE

A. All air balancing work shall be coordinated with other disciplines to comply with meeting or exceeding the minimum requirements of the Americans with Disabilities Act (ADA), Building Code, State Energy Code and local amendments. Final air balancing for all systems in each space shall be verified and adjusted as necessary to meet the following requirements during peak ventilation, smoke control mode, partial ventilation and minimum ventilation modes during occupied and non-occupied hours. The following requirements are provided as consolidated list of minimum ADA requirements:

1. The required force for pushing or pulling open a door other than fire doors shall not exceed 5 pounds.
2. At fire doors the required opening force shall not exceed 15 pounds.
3. At fire doors the doors shall be set in motion when subjected to a force not exceeding 30 pounds.
4. At fire doors the doors shall swing to a full open position when subjected to a force not exceeding 15 pounds.
5. The force to operate door latch releases shall not exceed 5 pounds.
6. The differential pressure between the building lobby and outside shall remain positive between 0.01” w.g., minimum, and 0.05” w.g., maximum, during operational hours.

3.6 AIR SYSTEM DATA

A. Report: The certified report shall include for each air handling system the data listed below.

1. Equipment (Fan or Factory Fabricated Station Unit):
   a. Installation data
      1) Manufacturer and model
      2) Size
      3) Arrangement, discharge and class
      4) Motor hp, voltage, phase, cycles, and full load amps
      5) Location and local identification data
b. Design data
   1) Data listed in schedules on drawings and specifications.

c. Fan recorded (test) data
   1) CFM
   2) Static pressure (suction and discharge, across each coil and filter set)
   3) RPM
   4) Motor operating amps
   5) Motor operating bhp

2. Duct Systems:
   a. Duct air quantities (maximum and minimum) - main, submains, branches, outdoor
      (outside) air, total air, and exhaust:
      1) Duct size(s)
      2) Number of pitot tube (pressure measurements)
      3) Sum of velocity measurements (Note: Do not add pressure measurements)
      4) Average velocity
      5) Recorded (test) cfm
      6) Design cfm

   b. Individual air terminals
      1) Terminal identification supply or exhaust, location and number designation
      2) Type size, manufacturer and catalog identification applicable factor for
         application, velocity, area, etc., and designated area
      3) Design and recorded velocities - fpm (state "core," "inlet," etc., as applicable)
      4) Design and recorded quantities - cfm (deflector vane or diffusion cone settings)

3.7 WATER SYSTEM PROCEDURES

A. Preparation:
   1. Open all valves to fully open position. Close coil bypass stop valves. Set mixing valve to
      full coil flow.
   2. Remove all strainers and clean same. Reinstall.
   3. Examine water system and determine if water has been treated and cleaned.
   4. Check pump rotation.
   5. Check expansion tank to determine they are not air bound and the system is completely
      full of water.
   6. Check all air vents at high points of water systems and determine that all are installed
      and operating freely.
   7. Check operation of automatic bypass valve.
   8. Operate each variable frequency drive (VFD) and verify controls installation is complete.
   9. Check and set operating temperatures of all equipment at design requirements.
   10. Complete air balance must have been accomplished before actual water balance begins.

B. Adjustment: All heating and cooling water systems shall be adjusted to provide required
    quantity to or through each component.

C. Automatic Controls: Automatic control valves shall be positioned for full flow through the heat
    transfer equipment of the system during tests.

D. Flow: Flow through bypass circuits at three-way valves shall be adjusted to equal that through
    the supply circuit, when the valve is in the bypass position.
E. Distribution: Adjustment of distribution shall be affected by means of balancing devices (cocks, valves, and fittings) and automatic flow control valves as provided. Manual service valves shall not be used for balancing.
   1. Where automatic flow control valves are utilized in lieu of Venturi tubes, only pressure differential need be recorded, provided that the pressure is at least the minimum applicable to the tag rating.

F. Special Procedures: Where available pump capacity (as designed) is less than total flow requirements of individual heat transfer units of system served, full flow may be simulated by the temporary restriction of flow to portions of the system; specific procedures shall be delineated in the agenda.

G. Water System Test and Balance Procedure: Perform the following tests, and balance each system in accordance with the following requirements:
   1. Set chilled & heating water pumps to proper gallons per minute delivery if necessary for balancing.
   2. Adjust chilled water flow through equipment
   3. Adjust heating water flow through equipment
   4. Test and record water temperatures at inlet and outlet side of each terminal unit. Note rise or drop of temperatures from source.
   5. Proceed to balance each terminal unit.
   6. Upon completion of flow readings and adjustments at coils, mark all settings and record data.
   7. After adjustments to coils are made, recheck settings at the pumps, chiller, boilers, and cooling towers and readjust if required.
   8. Record and check the following items at each coil.
      a. Inlet water temperatures.
      b. Leaving water temperatures.
      c. Water pressure drop of each coil.
   9. Pump operating suction and discharge pressures and final total dynamic head.
   10. List all mechanical specifications of pumps.
   11. Rated and actual running amperage of pump motor.
   12. Water metering device readings.

3.8 WATER SYSTEM DATA

A. Report: The certified report for each water system shall include the data listed below.
   1. Pumps:
      a. Installation data
         1) Manufacturer and model
         2) Size
         3) Type drive
         4) Motor hp, voltage, phase, and full load amps
      b. Design data
         1) GPM
         2) Head
         3) RPM and amps
      c. Recorded data
         1) Discharge pressures (full-flow and no-flow)
         2) Suction pressures (full-flow and no-flow) operating head
         3) Operating gpm (from pump curves if metering is not provided) no-load
         4) Amps
         5) Full-flow amps
         6) No-flow amps
2. Air Heating and Cooling Equipment:
   a. Design data
      1) Load in Btuh or MBh
      2) GPM
      3) Entering and leaving water temperature
      4) Entering and leaving air conditions (DB and WB)
      5) CFM
      6) Water pressure drop
      7) Entering steam pressure
   b. Recorded data
      1) Type of equipment and identification (location or number designation)
      2) Entering and leaving air conditions (DB and WB)
      3) Entering and leaving water temperatures
      4) GPM
      5) Temperature rise or drop
      6) Entering steam pressure

3.9 MEASUREMENT TOLERANCES

   A. Set system air flow rates and water flow rates within the following tolerances:
      1. Supply, return, and exhaust fans and equipment with fans: +/- 10%.
      2. Air outlets and inlets: +/- 10%.
      3. Heating water flow rate: +/- 10%.
      4. Chilled water flow rate: +/- 10%.

3.10 CERTIFIED REPORTS

   A. Submittals: Six (6) copies of the reports described herein, covering air and water system
      performance, air motion (fpm), and sound pressure levels, shall be submitted prior to final
      tests and inspection.

   B. Instrument Records: Types, serial numbers, and dates of calibration of all instruments shall be
      included.

   C. Reports: Reports shall conspicuously identify items not conforming to contract requirements,
      or obvious malfunction and design deficiencies.

   D. Certification: Certification shall include checking of adherence to agenda, of calculations, of
      procedures, and evaluation of final summaries.

3.11 FINAL COMMISSIONING TESTS, INSPECTIONS AND ACCEPTANCE

   A. Scope: Test shall be made to demonstrate that capacities and performance of air and water
      systems comply with contract requirements.
      1. At the time of final inspection, the Contractor shall recheck, random selection of data
         (water and air quantities, air motion, and sound levels) recorded in the certified report. In
         addition, all courtrooms, auditoriums, and conference rooms shall be rechecked.
      2. Points and areas for recheck shall be selected by the commissioning team.
      3. Measurement and test procedures shall be the same as approved for work forming basis
         of certified report.
      4. Selections for recheck (specific plus random), in general, will not exceed 25 percent of
         the total number tabulated in the report, except that special air systems may require a
         complete recheck for safety reasons.
B. Retests: If random tests elicit a measured flow deviation of 10 percent or more from design, or a sound level greater than 2 db or more than recorded in the certified report listings, as 10 percent or more of the rechecked selections, the report shall be automatically rejected. In the event the report is rejected, all systems shall be readjusted and tested, new data recorded, new certified reports submitted, and new inspection tests made, all at no additional cost. Retainage time shall be based on the date of the final acceptance of the certified report.

C. Marking of Settings: Following final acceptance of certified reports, the settings of all valves, splitters, dampers, and other adjustment devices shall be permanently marked by the Contractor so that adjustment can be restored if disturbed at any time. Devices shall not be marked until after final acceptance.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:
1. Ductwork Insulation:
   a. Duct wrap insulation.
   b. Acoustic duct lining.
   c. Rigid board ductwork and plenum insulation.
   d. Fire Rated duct insulation systems.
   e. Field applied jackets, indoor and outdoor.
2. Section Includes insulating the following duct services:
   a. All supply air ductwork, unless otherwise shown on drawings.
   b. Acoustical duct lining upstream/downstream of terminal equipment & fans

B. Types of mechanical insulation specified in this Section include the following:
1. Duct wrap insulation: Glass mineral wool also known as fiberglass.
2. Acoustic duct liner: Glass mineral wool also known as fiberglass.
3. Removable covers
4. Insulation accessories.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods.
B. Section 233113: Air Distribution.

1.4 DEFINITIONS

A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.
B. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.
C. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.
D. Freezing Climate: Where outdoor design temperature is less than 33°F, as stated in ASHRAE fundamentals under 99% column for winter design conditions.
E. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.
1.5 INSULATION INDUSTRY DEFINITIONS

A. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a Kraft paper interleaving with an outer film layer leaving no paper exposed.

B. ASJ: All Service Jacket (no outer film).

C. EPA: Environmental Protection Agency.

D. FHC: Fire Hazard Classification

E. FSK: Foil-Scrim-Kraft facing or vapor barrier.

F. FSP: Foil-Scrim-Polyethylene facing or vapor barrier.

G. ECOSE Technology: a proprietary binder system based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. ECOSE Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

H. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the “worst in class” materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.

I. PSK: Polypropylene-Scrim-Kraft facing or vapor barrier.

J. PVC: Polyvinyl Chloride.

K. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

L. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

M. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

N. SVF: Synthetic Vitreous Fiber including all forms of manufactured inorganic fibrous insulations such as glass wool (fiberglass) and mineral wool (rock wool and slag wool).

O. SSL+: Self-Sealing Lap with Advanced Closure System.

P. SSL: Self-Sealing Lap.


R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations.
S. UL Environment Claims Validation (ECV): service and label tests a manufacturer’s product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED-NC 2009 or New LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

T. UL GREENGUARD: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC’s), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.

U. UL GREENGUARD Gold Certification: (formerly known as GREENGUARD Children & Schools Certification) offers stricter certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is acceptable for use in environments such as schools and healthcare facilities. It is referenced by both The Collaborative for High Performance Schools (CHPS) and the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

V. WHO: World Health Organization.

1.6 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
      i. C303: Test Method for Density of Preformed Block-Type Thermal Insulation.
      j. C305: Test for Thermal Conductivity of Pipe Insulation.
      k. C356: Test for Linear Shrinkage of Preformed High-Temperature Thermal Insulation.


2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:


3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:


4. Underwriters Laboratory (UL): Manufacture and test insulation in accordance with the UL Standards, including:

   a. 181: Standard for Factory-Made Air Ducts and Air Connectors.


B. Installer Qualifications: 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.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.

D. Flame/Smoke Rating: Materials exposed within ducts or plenums shall be noncombustible. Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those
specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.


F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:
   1. Formaldehyde Free: Third party certified with UL Environment Validation or Scientific Certification Systems (SCS).
   2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products.

1.7 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation. Also, furnish necessary test data certified by an independent testing laboratory. Submit samples.
   1. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
      a. Pentabrominated diphenyl ether (CAS#32534-81-9).
      b. Octabrominated diphenyl ether (CAS#32536-52-0).
      c. Decabrominated diphenyl ether (CAS#1163-19-5).
   2. All materials, adhesives, mastics and sealants installed in California shall meet or exceed the minimum testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing and Evaluation of Volatile Organic Emissions from Indoor Sources using Environmental Chambers."

B. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.9 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.
PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with requirements in “PART 3 – EXECUTION” for Table 1, Table 2 and Table 3 for application of insulation materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall be certified UL GREENGUARD Gold or Indoor Advantage Gold if possible.

C. Insulation materials for use on austenitic stainless steel shall be qualified per ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Each insulation material has been provided a descriptive key code, such as DW-A, to simplify the organization and application of materials in following sub-sections.

F. Acceptable manufacturers include Knauf, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Reflectix or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each classification.

2.2 DUCT WRAP INSULATION (IDENTIFIED BY KEY CODE DW AND IN TABLE 1)

A. DW-A, Flexible Glass Mineral Wool Blanket:
   1. Application: Exterior insulation wrap for ductwork or other HVAC systems.
   2. Flexible Glass Mineral Wool Blanket bonded with a bio-based thermosetting resin:
   4. K-value: 0.29 Btu•in./hr•ft•°F at 75°F installed full thickness (maximum). Equivalent to “R-Value” per inch of 3.4 (hr•ft²•°F)/Btu•in. (minimum).
   5. Density: 0.75 lb./cu.ft. (minimum).
   6. Vapor Barrier Jacket: FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft. Or, PSK (Polypropylene-Scrim-Kraft) plastic vapor barrier.
   7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" section.
   8. Maximum operating temperature: 250°F.
   10. Smoke developed index: ASTM E84, less than 50.
   11. Manufacturers: Knauf Insulation #Atmosphere Duct Wrap, Owens Corning #SOFTR Duct Wrap, Johns Manville #Microlite FSK or PSK or equal.

2.3 ACOUSTIC DUCT LINER (IDENTIFIED BY KEY CODE ADL AND IN TABLE 3).

A. ADL-A, Glass Mineral Wool Acoustic Duct Liner:
   1. Application: Internal insulated duct lining for acoustic or thermal purposes.
   2. Fiberglass acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.
   5. K-value: 0.24 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to “R-Value” per inch of 4.2 (hr•ft²•°F)/Btu•in. (minimum).
   6. Water vapor absorption: ASTM C1104, less than 3% by weight.
7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.70 based on ASTM C423 Type “A” mounting.
8. Maximum velocity on mat or coated air side: 6,000 ft./min.
9. Surface burning: NFPA 90 A and 90B.
10. Maximum operating temperature: 250°F.
12. Smoke developed index: ASTM E84, less than 50.
13. Fasteners: Duct liner galvanized steel pins, welded or mechanically fastened.
14. Manufacturers: Johns Manville #Linacoustic RC, Knauf Insulation #Atmosphere with ECOSE, Owens Corning #QuietR Duct Liner HD or Duct Liner Board or equal.

2.4 RIGID FIBERGLASS BOARD DUCTWORK AND PLENUM INSULATION (IDENTIFIED BY KEY CODE RB BELOW AND IN TABLE 2)

A. RB–A, Rigid fiberglass duct board:
   1. Application: Rigid duct boards for insulating metal plenums and metal ductwork where rigidity is required.
   2. Fiberglass duct board with a bio based thermosetting resin.
   5. K-value: 0.23 Btu•in./(hr•ft²•°F) at 75°F (maximum). Equivalent to “R-Value” per inch of 4.3 (hr•ft²•°F)/Btu•in. (minimum).
   6. Water vapor absorption: ASTM C1104, less than 3% by weight.
   7. Noise Reduction Coefficient (NRC) equal to, or greater than, 0.75 based on ASTM C423 Type “A” mounting.
   8. Maximum velocity on mat or coated air side: 6,000 ft./min.
   9. Surface burning: NFPA 90 A and 90B.
  10. Maximum operating temperature: 250°F.
  12. Smoke developed index: ASTM E84, less than 50.
  14. Vapor Barrier Jacket: ASJ+ (All Service Jacket) or FSK (Foil-Scrim-Kraft) aluminum foil faced reinforced with glass mineral wool yarn and laminated to fire-resistant Kraft paper.
  15. Manufacturers: Knauf #Atmosphere Air Duct Board, Johns Manville #SuperDuct RC, Owens Corning #QuietR Duct Board, Certainteed #Ultra*Duct or equal.

2.5 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. Flexible Elastomeric and Polyolefin Adhesive:
   1. Comply with MIL-A-24179A, Type II, Class I.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturer: Aeroflex #Aeroseal, Armacell #Armaflex 520, H.B.Fuller #Foster 85-75, K-Flex #720-LVOC or equal.

C. Mineral-Fiber Adhesive:
   1. Comply with MIL-A-3316C, Class 2, Grade A.
   2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries # 22 Series or equal.

D. ASJ+ Adhesive, and FSK Jacket Adhesive:
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Manufacturer: H.B.Fuller #Childers Chil-Quik CP-127, H.B.Fuller #Foster 85-60 or 85-75, Mon-Eco Industries #22 Series or equal.

E. PVC Jacket Adhesive:
1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Manufacturer: Dow Corning #739 Plastic Adhesive, Johns Manville #Zeston Perma-Weld, Speedline #Polyco Adhesive Low VOC or equal.

2.6 MASTICS

A. Materials shall be compatible with ductwork material, insulation materials, jackets, and substrates and for sealing joints and seams.

B. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
1. Water-Vapor Permeance: ASTM E96/E96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: -20°F to +180°F (-29°C to +82°C).
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Manufacturer: H.B.Fuller #Foster 30-90, Vimasco #749 Vapor-Blok or equal.

D. Vapor-Barrier Mastic: Solvent based; suitable for indoor use.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
2. Service Temperature Range: 0 to 180°F (Minus 18 to plus 82°C).
5. Manufacturer: H.B.Fuller #Childers CP-30, H.B.Fuller #Foster 30-35, Mon-Eco Industries #55-10 or equal.

E. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use for below ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Manufacturer: H.B.Fuller #Foster 60-95/60-96 or equal.

F. Breather Mastic: Water based; suitable for indoor and outdoor use for above ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
5. Manufacturer: H.B.Fuller #Childers CP-10, H.B.Fuller #Foster 46-50, Mon-Eco Industries #55-50, Vimasco #WC-1 or WC-5 or equal.

2.7 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
   5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. Manufacturer: H. B. Fuller Company #Childers CP-76, Eagle Bridges - Marathon Industries #405, H. B. Fuller Company #Foster 95-44, Mon-Eco Industries, Inc. #44-05 or equal.

B. ASJ+ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
   5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. Manufacturer: H. B. Fuller Company #Childers CP-76 or equal.

2.8 SECUREMENTS

A. Bands:
   1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
   2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
   4. Manufacturer: ITW Insulation Systems, Gerrard Strapping and Seals, RPR Products #Insul-Mate Strapping or equal.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated. Manufacturer: AGM Industries, Inc. #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer. Manufacturer: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
   3. 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. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

d. Manufacturer: AGM Industries #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners #Spindle or equal.

4. 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. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.

b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

d. Manufacturer: GEMCO #Nylon Hangers, Midwest Fasteners #Nylon Insulation Hangers or equal.

5. 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. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12-gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

c. Adhesive: Adhesive-backed base with a peel-off protective cover.

d. Manufacturer: AGM Industries #Tactoo Self-Adhering Insul-Hangers, GEMCO; #Peel & Press, Midwest Fasteners #Self Stick or equal.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

b. Manufacturer: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

a. Manufacturer: GEMCO, Midwest Fasteners or equal.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel
2.9 LAGGING ADHESIVES

A. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.

B. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated per 40 CFR 59, Subpart D (EPA Method 24).
2. Service Temperature Range: 0 to +180°F (-18°C to +82°C).
4. Manufacturer: H.B.Fuller #Childers CP-50, H.B.Fuller #Foster 30-36, Vimasco #713 or 714 or equal.

2.10 FIELD APPLIED DUCTWORK INSULATION JACKETS

A. Field Applied Jackets (For Interior Applications):
1. All longitudinal seams shall be located on bottom of ductwork.
2. PVC Plastic: One-piece molded type fitting covers and jacketing material, gloss white. Connect with tacks and pressure sensitive color matching vinyl tape.
3. Manufacturer: Johns Manville #Zeston 2000 or equal.

2.11 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 C 1136, Type I.
2. ASJ+-SSL: ASJ+ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with Kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.12 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Metal Jacket:
   a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier: 3-mil (0.076 mm) thick polysurlyn.
2. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Sheet and roll stock ready for shop or field sizing or factory cut and rolled to size.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier: 3-mil (0.076 mm) thick polysurlyn.
3. Manufacturer: H. B. Fuller Company #Childers Metal Jacketing Systems, ITW Insulation Systems #Aluminum and Stainless Steel Jacketing, RPR Products #Insul-Mate or equal.

D. Self-Adhesive Outdoor Jacket:
   1. 60-mil (1.5 mm) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with stucco-embossed aluminum-foil facing.
   2. Manufacturer: Polyguard Products, Inc. #Alumaguard 60 or equal.

2.13 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 4 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts. Manufacturer: H. B. Fuller Company #Childers Chil-Glas No. 5 or equal.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts. Manufacturer: H. B. Fuller Company #Foster 42-24 Mast-A-Fab, Vimasco Corporation #Elastafab 894 or equal.

2.14 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd. (271 g/sq. m). Manufacturer: Alpha Associates, Inc. #84215/9383 or equal.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that ductwork has been tested for leakage in accordance with specifications before applying insulation materials. All ductwork shall be inspected by Owner's Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner's Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.

3.2 INSTALLATION

A. General:
   1. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.
   2. Remove and replace any insulation that has become wet or damaged during the construction process.
   3. Continue insulation and vapor barrier at penetrations and duct supports, except where prohibited by code. Instances where this is required include:
      a. Ductwork support angle or struts.
         1) To prevent crushing of low density insulation, provide separator or high density insulation at point of support. A 12 inch wide strip of 6 pcf density, glass mineral wool board or similar manufactured product, across the bottom side of the duct. Vapor barrier to continue unbroken at point of support.
2) As an alternative method, where the duct sits directly on the Unistrut or similar support, install board material on either side of the support to allow duct wrap to be tented over the support, providing a smooth transition over the support and maintaining thickness. Rigid 3 pcf board may be used in this method.

B. Insulation Applied on the Outside/Exterior of the Duct:
1. Provide insulated ductwork conveying air below ambient temperature (below room temperature) with vapor retardant jacket.
2. Seal all vapor retardant jacket seams and penetrations with 3" wide pressure-sensitive vapor barrier tape matching the insulation facing.
3. Where insulation is required, all ductwork, fittings, dampers, elbows, flexible ducts, rigid and flexible connectors, runouts, and devices shall be continuously insulated from fan systems to inlets/outlets to minimize heat transfer into ductwork and prevent condensation on exposed surfaces and as required to comply with applicable mechanical code and energy code.
4. Provide insulated ductwork conveying air above ambient temperature (above room temperature) with or without vapor retardant jacket. Where service access is required, bevel and seal ends of insulation.
5. Continue insulation through walls, sleeves, hangers, and other duct penetrations except where prohibited by code.
6. For ductwork exposed in mechanical equipment rooms below 7' or in finished spaces, finish with jacket material.
7. For interior vapor/moisture conveying duct applications, install glass mineral wool insulation unless specifically indicated otherwise on drawings. Install to meet manufacturer's requirements and as required by local code authorities.
8. Ducts installed exposed outside the building:
   a. For exterior applications where insulation is on the outside of the duct, provide insulation with a weather protection metal jacket or double wall construction.
   b. All exposed to weather exterior metallic ductwork exposed or covered with cladding is to be built with a crown or reverse cross break to shed moisture.

C. Installation of Mineral-Fiber Insulation (Blanket or Rigid Type):
1. Secure weld pins to duct using adhesive recommended for ductwork material. Pins shall be installed on a minimum of three sides of each duct to assure proper support. For overhead ductwork - pins are not required on the top of the ducts. For underfloor ducts - pins are not required on bottom side of ducts. For vertical ducts - pins are not required on surface facing wall. Install pins as follows:
   a. On duct sides with dimensions 18 inches (450 mm) and smaller: Place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) on center.
   b. On duct sides with dimensions larger than 18 inches (450 mm): Place pins 16 inches (400 mm) on center each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing and reinforcement points.
   c. Pins may be omitted from top surface of plenums.
   d. Do not over compress 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.
2. Install insulation with a continuous unbroken vapor barrier and insulation butted tight at each joint. Create a facing lap for longitudinal seams and end joints with insulation by removing up to 2 inches (50 mm) from one edge as required to allow stapling. Secure laps to adjacent insulation section with 1/2-inch (13 mm) outward-clinching staples, 6 inch
(150 mm) (maximum) on center. Staples may be omitted when closures are made by machine using heat-sensitive tape. 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.

3. 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.

4. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6 inch (150 mm) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) (maximum) on center.

D. Duct Liner-Insulation Applied on the Interior of the Duct:

1. Adhere insulation to sheet metal with a UL listed adhesive. Adhesive shall be applied to the sheet metal with a minimum coverage of 90%.

2. Secure insulation with mechanical liner fasteners as indicated by SMACNA or manufacturer. Pin length should be as recommended by the liner manufacturer.

3. All exposed edges of the liner must be factory or field coated. Unless factory coated, all transverse edges and longitudinal joints of the duct liner shall be coated. For systems operating at 2,000 fpm or higher, a metal nosing must be installed in all liner facing fan discharge or upstream of the airflow.

4. Repair liner surface penetrations with UL listed adhesive.

5. Duct dimensions indicated on plans are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.

6. Liner shall be folded and compressed into corners of rectangular duct or cut and fitted to assure a lapped compressed joint. Longitudinal joints should not occur in rectangular duct except at corners.

7. Longitudinal joints shall be coated with adhesive.

3.3 ENCAPSULATING NON-RATED PIPES AND CABLES

A. Where combustible non-fire rated pipes (plastic) and cables are installed in an air plenum space provide one layer of FRI-E fire barrier plenum wrap to fully encapsulate the item to comply with ASTM E84 or UL-723.

3.4 DUCTWORK INSULATION SCHEDULES

A. All insulation thicknesses shall meet or exceed latest edition of applicable ASHRAE 90.1, IECC, State Energy Code, Local Energy Code, and State Mechanical Code requirements as noted below. Minimum thermal resistance in range of 4.0 to 4.2 per inch of thickness. Insulation thicknesses are based on glass mineral wool insulation and may be adjusted for equivalent insulation values for materials with superior “K” factors.

B. The installed thickness of duct insulation used to determine its R-value shall be determined as follows:

1. For duct board, duct liner, and factory-made rigid ducts not normally subjected to compression, the nominal insulation thickness shall be used.

2. For duct wrap, installed thickness shall be assumed to be 75 percent (25 percent compression) of nominal thickness.

3. For factory-made flexible air ducts, the installed thickness shall be determined by dividing the difference between the actual outside diameter and nominal inside diameter by two.
C. All air distribution system ducts and plenums, but not limited to, building cavities, mechanical closets, air handler boxes, and support platforms used as ducts or plenums, shall be installed, sealed, and insulated to meet the requirements of the code. Portions of supply-air and return-air ducts conveying heated or cooled air located in one or more of the following spaces shall be insulated to a minimum level of R-8.

1. Outdoors; or,
2. In a space between the roof and an insulated ceiling; or,
3. In a space directly under a roof with fixed vents or openings to the outside or unconditioned spaces; or,
4. In an unconditioned crawlspace; or,
5. In other unconditioned spaces; or,
6. For buildings subject to compliance with the IECC in any location in Climate Zones 5 through 8 the insulation shall be 3” (R-12) minimum thickness for ductwork exterior to the building envelope.

D. TABLE 1: DUCT WRAP INSULATION SERVICE, THICKNESS, AND MATERIAL TYPE REQUIRED.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>R-Value (Minimum)</th>
<th>FINISH/JACKET</th>
<th>INSULATION KEY CODE AND REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply and/or return ductwork located outside to the building envelope.</td>
<td>R-8 minimum.</td>
<td>Metal jacket or galvanized sheet metal sandwich (double wall). Refer to drawings. Alternate option: pre-insulated duct system, refer to Section 233113 Air Distribution.</td>
<td>RB-A. Duct wrap or blanket with fabric or FSK jacket is not allowed.</td>
</tr>
</tbody>
</table>

Adjust insulation thicknesses as required to meet minimum R-Values.

E. TABLE 3: ACOUSTIC DUCT LINER SERVICE, THICKNESS, AND INSULATION TYPE REQUIRED.

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>THICKNESS (Minimum)</th>
<th>FINISH</th>
<th>INSULATION KEY CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside supply and return ducts within 10’ of fan power boxes and fans.</td>
<td>R-4.2</td>
<td>Air stream side mat or other fiber-free facing</td>
<td>ADL-A</td>
</tr>
</tbody>
</table>

Adjust insulation thicknesses as required to meet minimum R-Values.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

   A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, and Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

   A. All work to be furnished and installed under this Section shall include, but not necessarily be limited to, providing insulation for the following:

      1. Piping Insulation:
         a. Piping Insulation.
         b. Insulation Jackets.
         c. Removable Covers.
      2. Acoustic piping wrap
      3. Section includes the following HVAC piping systems:
         a. Heating hot water supply and return piping.
         b. Chilled water supply and return piping.
         c. Valves, pumps, air separators, strainers and fittings in insulated piping systems.

   B. Types of mechanical insulation specified in this Section include the following:

      1. Glass fiber.
      3. Closed cell phenolic.
      4. Polyisocyanurate.
      5. Flexible elastomeric closed cell foam.
      7. Insulation accessories.

1.3 RELATED WORK SPECIFIED ELSEWHERE

   A. Division 22: Plumbing.

   B. Section 230500: Basic HVAC Materials and Methods.

   C. Section 232113: Hydronic Piping, Valves and Specialties.

1.4 DEFINITIONS

   A. Ambient: The air temperature to be maintained in a conditioned room. Typically, between 70°F and 78°F.

   B. Insert: Spacer placed between the pipe support system and the piping to allow for the space required for insulation.

   C. Insulation Group (IG): Definition of Insulation Materials and Operating Temperatures.

   D. Insulation Shield: Buffer material placed between the pipe support system and the insulation to prevent the insulation material from crushing.
E. Jacket: Protective covering over the pipe insulation; may be factory applied such as “all service jacket” or field applied to provide additional protection; of such materials as canvas, PVC, aluminum or stainless steel.

F. Piping Insulation: Thermal insulation applied to prevent heat transmission to or from a piping system.

G. Vapor Barrier Jacket: Insulation jacket material that impedes the transmission of water vapor.

H. Freezing Climate: Where outdoor design temperature is less than 34°F (1°C), as stated in ASHRAE Fundamentals under 99% column for winter design conditions.

I. Unconditioned Space: any space not directly conditioned by mechanical equipment or maintained to temperature by mechanical equipment.

1.5 INSULATION INDUSTRY DEFINITIONS

A. Third Party Independent Product sustainable certification: Provides independent third-party, Indoor Air Quality (IAQ) certification of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Certification is based upon criteria used by EPA, OSHA, and WHO.
   1. UL GREENGUARD
   2. Scientific Certification Systems (SCS)

B. EPA: Environmental Protection Agency.

C. WHO: World Health Organization.

D. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film layer leaving no paper exposed.

E. ASJ: All Service Jacket (no outer film).

F. SSL+: Self-Sealing Lap with Advanced Closure System.

G. SSL: Self-Sealing Lap.

H. FSK: Foil Scrim Kraft; jacketing.

I. FSP: Foil Scrim Polyethylene jacketing

J. PSK: Poly Scrim Kraft; jacketing.

K. FHC: Fire Hazard Classification

L. PVC: Polyvinyl Chloride.

M. Bio based Binder Technology: binder systems based on rapidly renewable bio-based materials; rather than petroleum-based chemicals commonly used in other glass mineral wool insulation materials. Biobased Technology reduces the binder embodied energy by up to 70 percent and does not contain phenol, formaldehyde, acrylics or artificial colors.

N. UL GREENGUARD Gold Certification: Certification criteria, considers safety factors to account for sensitive individuals (such as children and the elderly), and ensures that a product is
acceptable for use in environments such as schools and healthcare facilities. It is referenced by the Leadership in Energy Environmental Design (LEED) Building Rating Systems.

O. Recycled Content – Post-Consumer: materials such as bottled glass collected at curbside or other collection sites after consumer use and used in the manufacturing process to create a new product rather than being placed in a landfill or incinerated.

P. Recycled Content – Pre-Consumer (aka Post-Industrial): materials used or created from one manufacturing process which are collected as scrap and placed back into another manufacturing process rather than being placed in a landfill or incinerated.

Q. Polybrominated diphenyl ethers (PBDE) such as Penta-BDE, Octa-BDE and Deca-BDE fire retardants: have been linked to adverse health effects after exposure in low concentrations.

R. UL Classified: UL has tested and evaluated samples of the product with respect to certain properties of the product. UL classifies products to applicable UL requirements standards for safety and standards of other National and International organizations

S. Imperative 11, Red List – requires that manufacturers disclose the ingredients in their products to document they are free of Red List chemicals and materials. The Red List represents the "worst in class" materials, chemicals and elements known to pose serious risks to human health and the greater ecosystem.


U. UL Environment Claims Validation (ECV): service and label tests a manufacturer’s product and validates that the environmental claims they make in their marketing and packaging materials are factual. This ECV service enables products to qualify for LEED® MR Credit 4 Recycled Content LEED V-4 Building product disclosure and optimization – sourcing of raw materials.

1.6 QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
1. American Society for Testing and Materials (ASTM): Manufacture and test insulation in accordance with the ASTM Standards, including:
   h. C303: Test Method for Density of Prefomed Block-Type Thermal Insulation.
   i. C305: Test for Thermal Conductivity of Pipe Insulation.
   k. C356: Test for Linear Shrinkage of Prefomed High-Temperature Thermal Insulation.


t. C553: Specification for Mineral Fiber Blanket-Type Pipe Insulation (Industrial Type).

u. C592: Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered).


2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): Provide and install pipe and duct insulation in accordance with the following ASHRAE Standard:


3. National Fire Protection Association (NFPA): Manufacture insulation in accordance with the following NFPA standards:


B. Installer Qualifications: 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.

C. Do not provide materials with flame proofing treatments subject to deterioration due to the effects of moisture or high humidity.
D. Flame/Smoke Rating: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method where installed in a return air plenum or in a ventilation intake or mechanical room. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.


F. Insulation thickness shall be the greater standard of that specified here or the State energy conservation requirements.

G. Sustainable Project Requirements:
   1. Formaldehyde Free: Third party certified with UL Environment or Scientific Certification Systems (SCS) Validation.
   2. Biosoluble: As determined by research conducted by the International Agency for Research on Cancer (IARC) and supported by revised reports from the National Toxicology Program (NTP) and the California Office of Environmental Health Hazard Assessment. Certified by European Certification Board for Mineral Wool Products (EUCEB).
   3. Low Emitting Materials: For all thermal and acoustical applications of Glass Mineral Wool Insulation Products, provide materials complying with the testing and products requirements of GREENGUARD Certification.

1.7 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, K-value, thickness, and furnished accessories for each mechanical system requiring insulation.

B. Products containing the following prohibited chemicals for use as flame retardants or for other purposes will not be acceptable when present in quantities greater than 0.1% by mass. Provide a statement with the submittal indicating that no product submitted contains an amount equal to or greater than 0.10% by mass of the following chemicals:
   1. Pentabrominated diphenyl ether (CAS#32534-81-9).
   2. Octabrominated diphenyl ether (CAS#32536-52-0).

C. Maintenance Data: Submit maintenance data and replacement material lists for each type of mechanical insulation. Include this data and product in maintenance manual.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coating to the site in containers with manufacturer's stamp or label affixed showing fire hazard indexes of products.

B. Store and protect insulation against dirt, water, chemical, and mechanical damage. Do not install damaged or wet insulation; remove from project site.
1.9 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Comply with requirements in "Part 3, Table 1: Piping Services, Fluid Temperature, and Insulation Type Required" for application of insulating materials.

B. Products shall not contain asbestos, lead, mercury or mercury compounds if possible. Products shall meet UL GREENGUARD certification standards for low-emitting products.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Each insulation material has been provided a descriptive key code, such as PI-A, to simplify the organization and application of materials in following sub-sections.

F. Thickness of insulation is based on meeting or exceeding the minimum requirement of applicable energy code and/or maximum allowable external temperature in relation to adjacent combustible material or other equipment. Exterior surface temperature shall not exceed 140°F at maximum operating capacity except as noted below for generator applications.

G. Acceptable manufacturers include Knauf Insulation, Johns Manville, Owens-Corning, Armstrong, Pittsburgh-Corning, Trymer, IIG, Certainteed, Halstead, Rubatex, 3M FireMaster, Pabco, Aeroflex, Armacell, Reflectix, Pacor or equal. Manufacturer and insulation types listed below indicate a minimum acceptable level of quality required for each product classification.

2.2 PIPE INSULATIONS (IDENTIFIED BY KEY CODE PI BELOW AND IN TABLE 1)

A. **PI-A**, Preformed Mineral Wool or Fiberglass:
   1. Materials: Mineral wool or fiberglass bonded with a thermosetting resin. Product to be validated GREENGUARD Gold for low VOC’s. In addition, pipe insulation to have a validated EPD from UL Environment or Scientific Certification Systems.
   2. Applications: Insulation of piping and fittings with thickness as required by local energy code.
   4. Compliant with ASTM C547 Type I, 850°F (454°C) or Type IV, 1000°F (538°C).
   5. Thermal conductivity (K-value): 0.24 Btu•in./(hr•ft•°F) or less, at 100°F (38°C).
   6. Service Temperature Range: 0°F to 850°F (-18°C to 454°C).
   7. Water Vapor Absorption, % of volume: <5% (maximum) as tested per ASTM C1104.
   8. Vapor Retarder Jacket: Factory applied ASJ or ASJ+ with SSL, white kraft paper interleaving reinforced with glass fiber scrim yarn and bonded to aluminum foil, secure with self-sealing longitudinal laps and butt strips.
   9. Water Vapor Permeance: 0.02 perms maximum.
10. Nominal density is 2.5 lbs./cu. ft., greater.
11. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
12. Manufacturers: Knauf #ECOSE Earthwool 1000*, Johns Manville #Micro-Lok or #Micro-Lok, Owens Corning, CertainTeed, Manson or equal.

B. **PI-B**, Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene:
1. Applications: Insulation of piping and fittings with thickness as required by local energy code.
2. Compliant with UL 181, ASTM C411, C518, C534, G21/C1338, G22, D1056 and E84.
4. Thermal Conductivity (K-value): 0.28 Btu•in./hr•ft²•°F or less, at 75°F (24°C).
5. Water Vapor Absorption, % of volume: <0.2% (maximum) compliant with ASTM C209.
6. Nominal density is 2.5 lbs./cu. ft. or greater.
7. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
8. Seal all seams and joints with contact adhesive or factory self-seal system with lap seal tape.
9. Manufacturers: Armacell #AP Armaflex, Rubatex #K-Flex ECO, Aeroflex #Aerocel or equal.

C. **PI-C**, Rigid Closed-Cell Phenolic Foam:
1. Applications: Insulation of piping and fittings with thickness as required by local energy code.
2. Compliant with ASTM C209, C518, C795, C1126, D1621, D1622, D2856, D6226 and E84.
4. Thermal conductivity (K-value): 0.18 Btu•in./hr•ft²•°F or less, at 75°F (24°C).
5. Vapor Retarder Jacket – straight sections: Factory applied ASJ with SSL.
6. Water Vapor Absorption, % of volume: <0.87% (maximum) as tested per ASTM C209.
7. Nominal density is 2.5 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
9. Manufacturers: ITW Trymer #Supercel, Kingspan #Koolphen K, Resolco #Insul-phen or equal.

D. **PI-D**, Rigid Closed-Cell Polysiocyanurate Foam:
1. Applications: Rigid preformed insulation of piping, fittings, vessels, and equipment with thickness as required by local energy code. Not for use in return air plenums or ventilation ductworks.
2. Compliant with ASTM C272, C591, C755, C1136, C920, D6226, E96, and E84.
3. Service Temperature Range: -297°F to 300°F (-183°C to 149°C).
4. Thermal conductivity (K-value): 0.19 Btu•in./hr•ft²•°F or less, at 75°F (24°C).
5. Water Absorption, % of volume: 0.7 (maximum) as tested per ASTM C272.
6. Vapor Retarder Jacket: Saran 540/SSL or Mylar laminate.
7. Nominal density is 2 lbs./cu. ft. or greater.
8. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤450 ratings as tested per ASTM E84. Not compliant for use in return air plenums.
2.3 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 C 1136, Type I.
2. ASJ+: White, polypropylene-coated, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
3. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
4. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
5. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
6. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.4 JACKETING MATERIALS

A. Field Applied Jackets (For Indoor Applications):

1. All longitudinal seams shall be located on bottom of pipes.
2. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
3. Aluminum Jacket:
   a. Comply with ASTM B209/B209M.
   b. Aluminum alloy 3003, 3005, 3105 or 5005 with an H-14 temper.
   c. Thickness: 0.016” thick sheet (minimum).
   d. Finish: Smooth or stucco embossed
   e. Moisture Barrier: 3 mil thick polysurlyn or 3 mil thick polyethylene.
   f. Longitudinal slip joints and 2” laps, die shaped fitting covers with factory attached protective liner. Secure with 3/8” or 1/2” stainless steel bands on 12” centers.
   g. Surface Burning Characteristics: Flame Spread Index ≤25 and Smoke Developed Index ≤50 ratings as tested per ASTM E84.
   h. Manufacturers: Pabco, Childers, RPR, ITW or equal.

B. Removable Covers:

1. Provide removable covers on indoor pumps, valves, air separators, air vent fittings, flanges, strainers, traps, etc., where periodic maintenance or removal of insulation is required.
   a. Pre-molded insulation covers:
      1) Cold Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      2) Cold Systems: Provide flexible closed cell foam or removable cloth insulating blankets for valves, pumps and strainers.
      3) Hot Systems: Provide PVC covers over insulated elbows, fittings and flanges.
      4) Hot Systems: Provide removable cloth insulating blankets on valves, pumps, and strainers.
   b. Removable cloth insulating blankets:
      1) Service Operating Temperature: 0-350°F.
      2) Jacket and Liner: silicon or teflon impregnated mineral wool cloth.
      3) Liner Reinforcement: stainless steel mesh cloth.
      4) Insulation: Fiberglass matt or Pacor #Aerogel, 2” thick (minimum) or R-8 equivalent (minimum), and thicker as required by local energy code.
      5) Fastening: 2” Nomex Velcro or 1” straps and stainless steel D-rings or 12-gage stainless steel hooks and stainless steel wire.
7) Outdoor Applications: Jacket shall be UV and ozone resistant with Velcro attachment.

2.5 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. Phenolic and Polyisocyanurate Adhesive:
   1. Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300°F (minus 59 to plus 149°C).
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Childers Brand #CP-96, Foster Brand #81-33 or equal.

C. Flexible Elastomeric and Polyolefin Adhesive:
   1. Comply with MIL-A-24179A, Type II, Class I.
   2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Manufacturers: Armaflex #520 Adhesive, Foster Brand #85-75, K-Flex USA #R-373, Aeroflex USA, Aeroseal, Armacell, or equal.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. PVC Jacket Adhesive: Compatible with PVC jacket.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
B. Vapor-Barrier Mastic: Water based for indoor use.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
   3. Vapor Safe Coating: Shall meet requirements of LEED IEQ Low-Emitting Materials. VOC 33 g/l, less water and exempt solvents.
   4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
   6. Manufacturers: Foster Brand #30-80/30-90, Vimasco Corporation #749 or equal.

C. Vapor-Barrier Mastic: Solvent based for outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
   2. Service Temperature Range: Minus 50 to plus 220°F (Minus 46 to plus 104°C).
   3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   5. Manufacturers: Childers Brand #Encacel X CP-40, Eagle Bridges - Marathon Industries #570, Foster Brand #60-95/60-96 or equal.

D. Breather Mastic: Water based for indoor and outdoor use.
   1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180°F (Minus 29 to plus 82°C).
   3. Solids Content: 60 percent by volume and 66 percent by weight.
   5. Manufacturers: Childers Brand #CP-10/CP-11, Eagle Bridges - Marathon Industries #550, Foster Brand #46-50, Mon-Eco Industries, Inc. #55-50, Vimasco Corporation #WC-1/WC-5 or equal.

2.7 LAGGING ADHESIVES

A. Adhesives shall be compatible with insulation materials, jackets, and substrates.
   2. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
   4. Service Temperature Range: 0 to 180°F (-18 to 82°C).
   6. Manufacturers: Childers Brand #CP-50 AHV2, Foster Brand #30-36, Vimasco Corporation #713/714 or equal.

2.8 SEALANTS

A. Joint Sealants:
      a. Manufacturers: Childers Brand #CP-76, Marathon Industries#405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05, Pittsburgh Corning Corporation #Pitseal 444 or equal.
   2. Joint Sealants for Polystyrene.
      a. Manufacturers: Childers Brand #CP-70, Marathon Industries #405, Foster Brand #30-45, Mon-Eco Industries, Inc.#44-05 or equal.
   3. Materials shall be compatible with insulation materials, jackets, and substrates.
   4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: -100 to 300°F (-73 to 149°C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Shall be compliant with requirements of LEED IEQ Low-Emitting Materials.

B. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76, Eagle Bridges - Marathon Industries #405, Foster Brand #95-44, Mon-Eco Industries, Inc. #44-05 or equal.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250°F (Minus 40 to plus 121°C).
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Manufacturers: Childers Brand #CP-76 or equal.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
   7. Manufacturers: ABI, Ideal Tape Division #428 AWF ASJ, Avery Dennison Corporation #Fasson 0836, Compac Corporation #105, 3M Venture Tape #1540 CW Plus/1542 CW Plus/1542 CW Plus/SQ or equal.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
   7. Manufacturers: ABI Tape #491 AWF FSK, Avery Dennison Corporation #Fasson 0827, Compac Corporation #110 and 111, 3M Venture Tape #1525 CW NT/1528 CW/1528 CW/SQ or equal.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
6. Manufacturers: ABI Tape #370 White PVC tape, Compac Corporation #130, Venture Tape #1506 CW NS or equal.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
6. Manufacturers: ABI Tape #488 AWF, Avery Dennison Corporation #Fasson 0800, Compac Corporation #120, 3M Venture Tape #3520 CW or equal.

2.10 SECUREMENTS

A. Bands:
1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304, 0.020 inch (0.50 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal.
2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   a. Manufacturers: AGM Industries #CWP-1, GEMCO #CD, Midwest Fasteners #CD, Nelson Stud Welding #TPA/TPC/TPS or equal.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   a. Manufacturers: AGM Industries #CHP-1, GEMCO #Cupped Head Weld Pin, Midwest Fasteners #Cupped Head, Nelson Stud Welding #CHP or equal.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel coordinated with application, fully annealed, 12 gauge, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   d. Manufacturers: AGM Industries, Inc. #Tactoo Perforated Base Insul-Hangers, GEMCO #Perforated Base, Midwest Fasteners, Inc.#Spindle or equal.
4. 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. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
   d. Manufacturers: GEMCO #Nylon Hangers, Midwest Fasteners, Inc.#Nylon Insulation Hangers or equal.

5. 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. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, as coordinated with application. 12 gauge, 0.106-inch - (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: back with a peel-off protective cover.
   d. Manufacturers: AGM Industries, Inc. #Tactoo Self-Adhering Insul-Hangers, GEMCO #Peel & Press, Midwest Fasteners #Self Stick or equal.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.015-inch- (0.41-mm-) thick, galvanized-steel, aluminum or stainless-steel sheet, as coordinated with application with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
   b. Manufacturers: AGM Industries #RC-150, GEMCO #R-150, Midwest Fasteners #WA-150, Nelson Stud Welding #Speed Clips or equal.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-(0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Manufacturers: GEMCO, Midwest Fasteners, Inc or equal.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.
   1. Manufacturers: C & F Wire or equal.

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that piping has been tested for leakage in accordance with specifications before applying insulation materials. All piping and ductwork shall be inspected by Owner’s Representative prior to installation of insulation. Any insulation applied prior to inspection shall be removed and new insulation applied at no additional cost to Owner. Notify Owner’s Representative five (5) working days prior to insulation installation.

B. Verify that all surfaces are clean, dry and free of foreign material.
3.2 INSTALLATION

A. General:
1. Install materials in accordance with manufacturer’s recommendations, building codes and industry standards.
2. Remove and replace any insulation that has become wet or damaged during the construction process.
3. Pipe fittings, valves, pipe flanges, pumps, strainers, gauge fittings, etc., shall be insulated to the same insulation thickness as adjoining piping and as required by local energy code. All support points, joints and fittings shall be insulated for continuous insulation coverage with no gaps or voids.

B. Piping Insulation:
1. Locate insulation and cover seams in least visible locations unless otherwise specified.
2. Neatly finish insulation at supports, protrusions, and interruptions.
3. Provide vapor retardant jackets with self-sealing laps on insulated cold pipes conveying fluids below ambient temperature. Insulate complete system. Staples used on pipes conveying fluids below ambient temperatures (cold systems) must be covered with approved mastic.
4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self-sealing lap or outward clinched, expanded staples. Seal ends of insulation at equipment, flanges, and unions.
5. Provide insert between support shield and piping on piping 1-1/2” diameter and larger. Fabricate insert using hydrous calcium silicate or other heavy density insulating material suitable for temperature and required insulation thickness. Insulation inserts shall not be less than the following lengths:
   a. 1-1/2” to 2-1/2” pipe size: 10” or longer.
   b. 3” to 6” pipe size: 12” or longer.
   c. 8” to 10” pipe size: 16” or longer.
   d. 12” pipe size and larger: 22” or longer.
6. For smaller pipe sizes, less than 1-1/2” diameter, provide metal or pre-manufactured plastic insulation shield to support the insulated pipe through the support point at the hanger or saddle. Pipe shield shall be a minimum of 6” long to distribute the weight of the insulated pipe without crushing or damaging the insulation. Pipe shield shall be located outside of the metal insulation jacket where applicable.
7. Use of metal saddles is acceptable as specified in Section 230500. Fill interior voids with segments of insulation matching adjoining pipe insulation.
8. Use of pipe hangers designed as an insulation coupling is acceptable in lieu of saddles and other devices.
9. For insulated pipe exposed in mechanical equipment rooms or in finished spaces below seven (7) feet above finished floor, cover insulation with PVC or metal jacketing.
10. Where pumps, valves (manual and control types), strainers, etc., with insulation require periodic opening for maintenance, repair or cleaning, install insulation in such a manner that it can be easily removed and replaced without damage.
11. For exterior applications:
   a. Apply weather-resistant protective finish to flexible elastomeric insulation. Insulation seams shall be located on the bottom side of horizontal piping.
   b. All lateral and longitudinal insulation joints to be sealed with low VOC, UV inhibitive adhesive.
   c. Provide weather protection jacket over insulation. Insulated pipe lengths, pumps, fittings, joints, and valves shall be covered with aluminum jacket or stainless steel jacket. PVC or plastic jackets are not allowed exterior to the building. Jacket seams
shall be located on bottom side of horizontal piping. All lateral jacket joints shall be caulked with a minimum 20-year silicone sealant (clear). All longitudinal jacket joints, except those at the bottom of a horizontal pipe run, shall be caulked with a minimum 20-year silicone sealant (clear).

12. For underground installations, install per manufacturer’s written instructions and recommendations.

13. When maintenance or service access for equipment will result in foot traffic over floor mounted insulated piping the contractor is to fabricate a permanent removable walkway to prevent damage to the piping and insulation.

14. Special Application Requirements for Chilled Water Systems:
   b. 90/45/tee fittings: Provide material routed out of bun stock to the shape of the elbow, cut in half and applied to the fitting and spiral wrapped with vapor retarder tape. Cover with PVC fitting cover.
   c. Installation shall conform to insulation manufacturer’s installation guide.
   d. Longitudinal jacket laps for pipe insulation installed on piping systems with operating temperatures below ambient shall be vapor sealed with factory-applied pressure-sensitive adhesive vapor retarder, self-sealing lap. For proper sealing, firmly rub lap joints with reasonable pressure being applied with a plastic squeegee or sealing tool. Vapor seal all circumferential joints with factory-furnished, matching pressure-sensitive butt strips installed with reasonable pressure being applied with a plastic squeegee or sealing tool. Additionally, coat raw edges of pipe insulation sections with vapor retarder mastic at 12 foot to 21 foot intervals; at Engineer’s discretion on straight piping, and on either side of all fittings, flanges or valves. Vapor retarder mastic shall completely coat the ends of the pipe and extend onto the bore of the pipe insulation and onto the jacketing a minimum of 2 inches.
   e. Where pipe attachments or seismic supports are bolted or welded directly to the pipe provide insulation and vapor barrier around such metal support elements, that extend beyond the pipe insulation, as required to prevent condensation from forming on exposed metal and bolts.

15. Jacket Locations for Pipe, Valve and Fittings. Provide protective insulation jackets for the following locations where not defined elsewhere in the specifications for piping systems:

<table>
<thead>
<tr>
<th>Insulation Jacket Location</th>
<th>Jacket Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoors: Concealed in Accessible Ceiling Voids</td>
<td>None</td>
</tr>
<tr>
<td>Indoors: Concealed in Inaccessible Ceiling Voids</td>
<td>None</td>
</tr>
<tr>
<td>Indoors: Concealed in Accessible Portions of Shafts or Chaseways</td>
<td>None</td>
</tr>
<tr>
<td>Indoors: Concealed in Inaccessible Portions of Shafts or Chaseways</td>
<td>None</td>
</tr>
<tr>
<td>Indoors: Exposed to view in warehouse, storage and manufacturing spaces</td>
<td>None</td>
</tr>
</tbody>
</table>

3.3 PIPING INSULATION SCHEDULE

A. TABLE 1: PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED.
   1. All insulation thicknesses shall meet or exceed state energy code requirements as noted below. Increase thickness by 1/2” (minimum) where insulated pipe is exposed to exterior ambient air. Minimum thermal resistance shall comply with building code minimum ranges and may exceed those minimum levels. Insulation thicknesses may be adjusted for equivalent insulation values for materials with superior “K” factors. Refer to "PART 2-PRODUCTS" for characteristics of each insulation material listed below.
PIPE INSULATION INDEX

<table>
<thead>
<tr>
<th>INSULATION KEY CODE</th>
<th>INSULATION TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI-A</td>
<td>Preformed Flexible Mineral Wool or Fiberglass.</td>
</tr>
<tr>
<td>PI-B</td>
<td>Preformed Flexible Closed-Cell Elastomeric, Neoprene or Polyethylene.</td>
</tr>
<tr>
<td>PI-C</td>
<td>Preformed Rigid Closed-Cell Phenolic Foam.</td>
</tr>
<tr>
<td>PI-D</td>
<td>Preformed Rigid Closed-Cell Polyisocyanurate Foam. Limited to non-plenum rated applications.</td>
</tr>
<tr>
<td>PI-F</td>
<td>Rigid Closed-Cell Cellular Glass.</td>
</tr>
</tbody>
</table>

### TABLE 1:
**PIPING SERVICES, FLUID TEMPERATURE, AND INSULATION TYPE REQUIRED**

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>INSULATION KEY CODE</th>
<th>THICKNESS/REMARKS (Minimum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chilled water supply and return systems and fittings (40°F to 60°F).</td>
<td>PI-B, C, D, F</td>
<td>Thickness as required by State Energy Code. See Table 2 below.</td>
</tr>
<tr>
<td>Heating water supply and return systems and fittings (up to 200°F).</td>
<td>PI-A, B, C, D,F</td>
<td>Thickness as required by State Energy Code. See Table 2 below.</td>
</tr>
</tbody>
</table>

### B. TABLE 2: MINIMUM PIPING INSULATION THICKNESS BASED ON FLUID TEMPERATURE AND PIPING SIZE.

#### 1. Washington

<table>
<thead>
<tr>
<th>FLUID TEMPERATURE RANGE (°F)</th>
<th>CONDUCTIVITY RANGE (in Btu-inch per hour per square foot °F)</th>
<th>INSULATION MEAN RATING TEMPERATURE (°F)</th>
<th>NOMINAL PIPE DIAMETER (in inches)</th>
<th>INSULATION THICKNESS REQUIRED (in inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Less than 1</td>
<td>1 and 1-1/4</td>
</tr>
<tr>
<td>Space heating systems</td>
<td></td>
<td></td>
<td>105-140</td>
<td>0.21-0.28</td>
</tr>
<tr>
<td>Space cooling systems (chilled water)</td>
<td></td>
<td></td>
<td>40-60</td>
<td>0.21-0.27</td>
</tr>
</tbody>
</table>

**END OF SECTION**
PART 1  GENERAL

1.1  APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2  SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include but not necessarily be limited to the following:
   1. Provide new controls components & BAS graphics for new equipment as part of this scope of work, integrate with existing JCI control system in Discovery Hall. Scope is included but not limited to; hardware, software, controller, devices, sensors, conduit, wiring, and labor as required to provide complete and operational systems.

B. General Requirements
   1. The work includes designing, providing and installing a complete and fully operable building automation system as described in this Section of the Specification and as shown on the contract construction drawings and shall be in accordance with rules, regulations and standards as required by the authorities having jurisdiction. Any alternations to the quantity or location of the control panels shall be coordinated with the Electrical Contractor and General Contractor prior to bidding. Any BAS changes after bidding must be coordinated with Electrical Contractor and General Contractor at no additional cost to Owner.
   2. Submit shop drawings of the entire control system components fully coordinated with major equipment suppliers' requirements. Provide proposed programming logic sequences of control functions on each system.
   3. Installation of control components other than valves, dampers and sensing wells as required for a complete and workable system.
   4. This Contractor shall furnish, install and coordinate the interlock and control wiring as specified and/or required for a complete and workable control system.
   5. Controls dampers are specified and furnished in Section 233113 of these specifications. Provide damper actuators, wiring and conduit as required to operate all dampers as shown.
   6. Upon completion of the installation, data entry and programming, provide complete validation and adjustment of specified control system through period of testing and Owner's acceptance. The control contractor shall perform a point-to-point check out of all newly installed points to verify point existence, proper end to end connection and correct SI units with the Owners Representative.
   7. The entire program and sequence of operation with the final points list shall be verified by the Control Contractor, the Owner's Representative, and signed by both parties. A copy of the final program, sequence of operation, and points list shall be submitted to the Engineer for approval and inclusion with the operation and maintenance manuals.
   8. Owner training on operation of the control system.
   9. One-year warranty on workmanship and materials.
   10. Interlocking of electrical systems and motors as shown on Drawings, except where specifically shown on electrical drawings.
1.3 RELATED WORK IN OTHER SECTIONS

A. Refer to Division 0 and Division 1 for related contractual requirements.

B. Provide certificates of calibration for all sensors required for control and monitoring including temperature and pressure.

C. Refer to Division 23 and the following sections for Mechanical or Electrical Provision.
   1. Division 01 - Submittal Procedures
   2. Division 01 - Commissioning
   3. Section 230500: Basic HVAC Materials and Methods
   4. Section 230593: Testing, Adjusting, and Balancing
   5. Section 230902: Variable Frequency Drives
   6. Section 232113: Hydronic Piping, Valves and Specialties
   7. Section 233113: Air Distribution
   8. Sections 237000 through 238999 equipment
   9. Division 26 – Electrical Materials and Methods
   10. Division 28 – Electronic Safety and Security

D. Refer to Division 26 sections for Electrical Provisions. Sources of 120-volt electrical power as indicated on the electrical drawings and specifications for control system components furnished by this section. The controls contractor shall be responsible for all additional electrical distribution from these connection points to the control panels and other controls devices.

E. BAS contractor will furnish, but not install the following:
   1. Hydronic pressure and temperature sensor wells: furnish to mechanical installer and coordinate per manufacturer’s requirements.
   2. Control valves: furnish to mechanical installer and coordinate per manufacturer’s requirements.

1.4 REFERENCE STANDARDS

A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
   1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
   3. International Building Code (IBC), including local State and Local amendments.
   4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
   6. FCC Part 15, Subpart J, Class A.
   8. UL-864 UUKL listing for Smoke Controls for any equipment used in smoke control sequences.

B. City, county, state, and federal regulations and codes in effect as of contract date.

C. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.
1.5 DEFINITIONS

A. ASHRAE: American Society of Heating, Refrigerating, and Air-conditioning Engineers

B. BACnet: BACnet is a preferred communications protocol for building automation and control networks. It is an ASHRAE, ANSI, and ISO standard protocol. BACnet MS/TP is utilized with EIA/RS 485 hardware and BACnet/IP with Ethernet.

C. BAS: A system that optimizes the start-up and performance of HVAC equipment and alarm systems. A BAS greatly increases the interaction between the mechanical subsystems of a building, improves occupant comfort, lowers energy use, and allows off-site building control.

D. Modbus: One of industry standard communication protocols supported by NTMC. Developed by Modicon, Inc., North Andover, MA.

E. ODVA™: (Open DeviceNet Vendors Association) An international organization that supports computing network technologies based upon the Common Industrial Protocol (CIP). These include DeviceNet, EtherNet/IP, CIP Safety and CIP Sync.

F. RTD: Resistance temperature detector is a sensor whose resistance changes with temperature.

G. SCADA System (Supervisory Control And Data Acquisition): A type of industrial control system; a computer system which monitors and controls industrial, infrastructure, or facility-based processes.

H. Transducer: A device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa.

I. Transmitter: A set of equipment used to generate and transmit electromagnetic waves carrying messages or signals.

1.6 GENERAL REQUIREMENTS

A. Furnish a distributed logic BACnet-based control system including operator’s workstation. The operator’s workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2012, BACnet. Provide all necessary BACnet-compliant hardware and software to meet the system’s functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.

B. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.

C. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.

D. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.

E. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.
F. Provide and install all interconnecting cables between all operator’s terminals and peripheral devices (such as printers, etc.) supplied under this section.

G. Provide complete manufacturer’s specifications for all items that are supplied. Include vendor name of every item supplied.

H. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.

I. Provide a comprehensive operator and technician training program as described herein.

J. Provide as-built documentation, operator’s terminal software, a software key for a minimum of one additional computer (coordinate with Owner’s Representative if additional keys are required), diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

K. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.7 SYSTEM DESCRIPTION

A. A distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2012, BACnet and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, fan-coils, air handlers, boilers, chillers, and any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.

B. The Building Automation System (BAS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, after-hours billing program, demand limiting, and a full suite of field engineering tools including graphical programming and applications.

C. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator’s terminal. Operator’s terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.

D. All application controllers for every piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through BACnet LAN.

E. Room sensors shall be provided with digital readout that allow the user to view room temperature, CO2 or relative humidity, adjust the room setpoint within preset limits and set desired override time. User shall also be able to start and stop unit from the digital sensor. Include all necessary wiring and firmware such that room sensor includes field service mode. Field service mode shall allow a technician to balance VAV zones and access any parameter
in zone controller directly from the room sensor. Field service mode shall have the ability to be locked out.

1.8 QUALITY ASSURANCE

A. The BAS shall be designed, installed, commissioned, and serviced by contractor authorized and trained personnel. System provider shall have an in-place support facility within two (2) hours response time of the site with technical staff, spare parts inventory, and necessary test and diagnostic equipment.

B. The manufacturer and installer shall have a minimum of 5 years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. A list of successful past projects of similar type, size and complexity shall be submitted. In addition, a reference list of names, addresses and telephone numbers of the design Engineer and the Owner’s Representative for each installation shall be provided. The references may be contacted and questioned about the timely delivery, installation, operation and service received for each installation.

C. The contractor shall provide experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.

D. The Bidder shall be regularly engaged in the design, installation and maintenance of BAS systems and shall have demonstrated technical expertise and experience in the manufacture, installation and maintenance of BAS systems similar in size and complexity to this project. Bidders shall provide a list of at least 10 projects, similar in size and scope to this project completed within the past 3 years.

E. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.

F. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. Control system shall be engineered, programmed and supported completely by representative’s local office that must be within 100 miles of project site.

I. Control components shall be products of the same manufacturer only, unless indicated otherwise and approved by Owner’s Representative. Example – all valves shall by one manufacturer and all temperature sensors shall be by one manufacturer.

1.9 SUBMITTALS

A. Drawings
   1. The system supplier shall submit point-to-point engineered drawings, control sequence, and bill of materials for approval.
   2. Drawings shall be submitted in a standard size of 11” x 17” (ANSI B), or larger.
   3. Eight complete sets (copies) of submittal drawings shall be provided.
   4. Drawings shall be available on portable memory device, DVD or CD disk media.
B. System Documentation
   1. Include the following in submittal package:
      a. System configuration diagrams in simplified block format.
      b. All input/output object listings and an alarm point summary listing.
      c. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
      d. Complete bill of materials, valve schedule with Cv, valve pressure drop at design flow, and damper schedule.
      e. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
      f. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
      g. For all system elements—operator's workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2012.
      h. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
      i. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management
   1. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

1.10 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Warrant work as follows:
   1. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
   2. Warrant all actuators for a period of five (5) years.
   3. Respond during normal business hours within 24 hours of Owner's warranty service request.
   4. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
   5. If Owner's Representative determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Owner's Representative will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
   6. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
7. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable BAS Manufacturers include:
   1. JCI Metasys

2.2 WEB INTERFACE

A. General
   1. BAS supplier shall provide Web-based access to the system as part of standard installation. User must be able to access all displays of real-time data that are part of the BAS using a standard Web browser. Web browser shall tie into the network through Owner-supplied Ethernet network connection. Web page host may be a separate device that resides on the BAS BACnet network, but is not the BAS server for the control system. BAS server may be a separate computer from the Web page host device. The Web page software shall not require a per-user licensing fee or annual fees. The Web page host must be able to support simultaneous users with the ability to expand the system to accommodate an unlimited number of users.

B. Browser Technology
   1. No special vendor-supplied software shall be needed on computers running browser. All displays shall be viewable and the webpage host shall directly access real-time data from the BAS BACnet network. Data shall be displayed in real-time and update automatically without user interaction. User shall be able to change data on displays if logged in with the appropriate user name and password.

C. Communications
   1. Web page host shall support Ethernet network connections. A network connection shall be used to gather real-time data from all the BACnet devices that form the BAS. This network shall communicate using BACnet, allowing the Web page host to gather data directly from units on the local LAN or from other projects connected over a WAN. This network shall also provide the connection to the BAS server for Web page generation.
   2. An Ethernet connection shall provide the physical connection to the Internet or an IP-based WAN. It shall be the port that is used for the browser to receive Web pages and data from the Web page host. The Web page host shall act as a physical barrier between the BAS network and the WAN or Internet connection that allows the browser to receive Web pages and data. The two separate network connections provide for a physical barrier to prevent raw BACnet traffic being exposed on the IP network.
   3. The Web page host shall provide for complete isolation of the IP and BACnet networks by not routing networking packets between the two networks.

D. Display of Data
   1. Web page graphics shown on browser shall be replicas of the BAS displays. User shall need no additional training to understand information presented on Web pages when compared to what is shown on BAS displays. Web page displays shall include animation just as BAS displays. Fans shall turn, pilot lights shall blink, coils shall change colors, and so on.
   2. Real-time data shall be shown on all browser Web pages. This data must be directly gathered using the BACnet network and automatically updated on browser Web page
displays without any user action. Data on the browser shall automatically refresh as changes are detected without re-drawing the complete display.

3. It shall be possible for user from browser Web page to change data if the user is logged on with the appropriate password. Clicking on a button or typing in a new value shall change digital data. Using pull-down menus or typing in a new value shall change analog data.

4. Data displays shall be navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

E. Time Schedule Adjustment
1. Web access shall allow user to view and edit all schedules in the system. This includes three types of schedules: standard, holiday and event. Display of schedules shall show interaction of all schedules on a single display so user sees an overview of how all work together. User shall be able to edit schedules from this display.

2. Display of all three schedule types must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.

3. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

F. Logging of Information
1. User shall use standard browser technology to view all trendlogs in system. User shall be able to view logged data in tabular form or graphical format. User shall be able to adjust time interval of logged data viewed and shall be able to adjust Y axis of data viewed in graphical format. User shall also be able to download data through the Web interface to local computer. Data shall be in CSV format.

G. Alarm Handling
1. Web interface shall display alarms as they occur. User shall be able to acknowledge alarms using browser technology. In addition, user shall be able to view history of alarm occurrence over a user-selected time frame. In addition, those alarms may be filtered for viewing per user-selected options. A single selection shall display all alarms that have not been acknowledged.

H. Web Page Generation
1. Web pages shall be automatically generated from the BAS displays that reside on the BAS server. User shall access Web page host through the network and shall initiate a Web page generation utility that automatically takes the BAS displays and turns them into Web pages. The Web pages generated are automatically installed on the Web page host for access using any computer’s standard browser. Any system that requires use of an HTML editor for generation of Web pages shall not be considered.

I. Password Security and Activity Log
1. Access through Web browser shall utilize the same hierarchical security scheme as BAS system. User shall be asked to log on once the browser makes connection to Web page host. Once the user logs in, any and all changes that are made shall be tracked by the BAS system. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have
logged in to the system, regardless of whether those changes were made using a browser or through the BAS workstation.

J. BACnet Communication
1. Web server shall directly communicate to all devices on the BAS network using BACnet protocol. No intermediate devices shall be necessary for BACnet communication.

2.3 BUILDING NETWORK CONTROLLER

A. Building Network Controller
1. BACnet Conformance
   a. Building Network Controller shall be approved by the BACnet Testing Laboratories as meeting the BACnet Building Controller requirements.

B. Building network controller modules shall provide normal 7-day scheduling, holiday scheduling and event scheduling.
1. Logging Capabilities
   a. Logs shall be supported in the building network controller. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator’s workstation.
   b. Logs may be viewed both on-site or off-site using WAN or remote communication.
   c. Building network controller shall periodically upload trended data to networked operator’s workstation for long-term archiving if desired.
   d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

2. Alarm Generation
   a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
   b. Each alarm may be dialed out as noted elsewhere.
   c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator’s terminal or off-site using remote communications.
   d. Controller must store alarms as BACnet event enrollment objects, with system destination and actions individually configurable.

3. Demand Limiting
   a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 200 loads using a minimum of two types of shed programs.
   b. Load shedding programs in building controller modules shall operate as coordinated with local utility.

C. Ethernet – MS/TP Module
1. Ethernet – MS/TP Module shall support every function as listed under paragraph A, General Requirements, of this section and the following.

2. All communication with operator’s workstation and all application controllers shall be through BACnet. Building controller Ethernet – MS/TP module shall incorporate as a minimum, the functions of a 2-way BACnet router. Controller shall route BACnet messages between the high-speed LAN (Ethernet 10/100MHz) and MS/TP LAN. Ethernet – MS/TP module shall also route messages from all other building controller modules onto the BACnet Ethernet network.
   a. MS/TP LAN must be software-configurable from 9.6 to 76.8Kbps.
   b. The RJ-45 Ethernet connection must accept either 10Base-T or 100Base-TX BACnet over twisted pair cable (UTP).
D. MS/TP Module
   1. MS/TP module shall support every listed function in this specification and the following.
   2. Building controller MS/TP module communications shall be through BACnet MS/TP LAN to all advanced application and application-specific controllers. MS/TP module shall also route messages to Ethernet – MS/TP module for communication over WAN.
      a. MS/TP LAN must be software configurable from 9.6 to 76.8Kbps.
      b. Configuration shall be through RS-232 connection.

E. Power Supply Module
   1. Input for power shall accept between 17–30VAC, 47–65Hz.
   2. Power supply module shall include rechargeable battery for orderly shutdown of controller modules including storage of all data in flash memory and for continuous operation of real-time clocks for minimum of 20 days.

F. Modbus Module
   1. Modbus Module shall support every function as listed in this specification.
   2. Building Controller Modbus module communications shall be via one of three types of ports: EIA-485, EIA-422 or RS-232 connection. Modbus module shall convert Modbus data into BACnet objects. Modbus module shall also route messages to Ethernet-MS/TP module for BACnet Ethernet communication over WAN.
      a. Modbus Module shall support ASCII or RTU Modbus communication at 9600 or 4800 baud.
      b. EIA-422 and EIA-232 connection shall support one connection of Modbus unit.
      c. EIA-485 connection shall support connection of up to 247 Modbus units.
      d. Configuration shall be via RS-232 connection.
   3. BACnet Translation
      a. All Modbus data shall be translated into BACnet objects by the Modbus module. All configuration tools shall be supplied to assure data is translated as necessary to the correct format and value.
      b. Standard BACnet object types supported shall include as a minimum: Analog Value, Binary Value, Calendar, Device, File, Group, Notification Class, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

2.4 APPLICATION CONTROLLERS – GENERAL

A. All application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of 3 pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.

B. All program sequences shall be stored on board controller in memory. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller ten(10) times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
C. Provide all application controllers with a minimum of 10% spare points for analog input, analog output, digital input and digital output signals.

2.5 APPLICATION CONTROLLER – UNITARY MECHANICAL EQUIPMENT

A. Provide one native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

2.6 APPLICATION CONTROLLER – VAV BOX SINGLE DUCT AND/OR FAN POWER BOXES

A. Provide one native BACnet application controller for each VAV box that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include onboard CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.

B. On board flow sensor shall be microprocessor-driven and pre-calibrated at the factory. All factory calibration data shall be stored in non-volatile memory. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator’s workstation, portable computers, and special hand-held field tools shall not be needed for field calibration.

C. Provide duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator’s workstation.

2.7 AUXILIARY CONTROL DEVICES

A. Temperature Sensors (TS)

1. Duct air temperature (duct mounted, indoor location)
   a. Thermistor type with 1/4” stainless steel probe and junction box. 10K ohm, Type II, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend 25% (minimum) to 50% (maximum) into the width of duct. Manufacturer: Veris #TF Series, Dwyer Instruments #TE-DFG Series, Kele (Minco) #TT Series, or equal.

2. Duct air temperature (duct mounted, outdoor location)
   a. Thermistor type with 1/4” stainless steel probe and weather-tight junction box. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend 25% (minimum) to 50% (maximum) into the width of duct. Manufacturer: Veris #TG Series, Dwyer Instruments #TE-DFW Series, Kele (Minco) #TT Series, or equal.

3. Pipe or tank fluid temperature (immersion probe)
   a. Immersion probe type temperature sensor encased in a corrosion-resistant stainless steel thermowell. Thermistor type with metallic housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Manufacturer: Veris #TIG Series, Dwyer Instruments #TE Series, or equal.

4. Temperature averaging (coil mounting)
   a. Thermistor type with bendable copper tubing element water-resistant junction box. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA. Probe length as required to extend across coil face at least twice to cover two corners and one midpoint. Mounting of tubing shall utilize Veris #AA64 mounting clips, or equal. Manufacturer: Veris #TA Series, Kele #AC1 Series, or equal.
B. Intelligent Room Temperature Sensor (TS) with LCD Readout
   1. Sensor shall contain a backlit LCD digital display and user function keys along with temperature sensor. Controller shall function as room control unit and allow occupant to raise and lower setpoint, and activate terminal unit for override use—all within limits as programmed by building operator. Sensor shall also allow service technician access to hidden functions as described in sequence of operation.
   2. The intelligent room sensor shall simultaneously display room setpoint, room temperature, outside temperature, and fan status (if applicable) at each controller. This unit shall be programmable, allowing site developers the flexibility to configure the display to match their application. The site developer should be able to program the unit to display time-of-day, room humidity and outdoor humidity. Unit must have the capability to show temperatures in degrees Fahrenheit or Centigrade.
   3. Override time may be set and viewed in half-hour increments. Override time countdown shall be automatic, but may be reset to zero by occupant from the sensor. Time remaining shall be displayed. Display shall show the word “OFF” in unoccupied mode unless a function button is pressed.
   4. See sequence of operation for specific operation of LCD displays and function keys in field service mode and in normal occupant mode. Provide intelligent room sensors as specified in point list. Field service mode shall be customizable to fit different applications. If intelligent room sensor is connected to VAV controller, VAV box shall be balanced and all air flow parameters shall be viewed and set from the intelligent room sensor with no computer or other field service tool needed.

C. Dew Point Sensor (Pipe Strap Mounted Indoors):
   1. Early-warning dew point switch to monitor chilled water pipes. Strap on mounting, status light, NO and NC alarm terminals, 24 VAC/0.3 VA.
   2. Manufacturers: Honeywell #HSS-DPS or equal.

D. CO2 Sensors
   1. Indoor space measurement (wall mounted):
      a. Non-dispersive infrared sensor in high impact white ABS plastic enclosure. Input power 20 to 30 VDC/24 AC, 100 mA. Analog output 4-20 mA. Operating range 32°F to 122°F (0°C to 50°C). Measurement range of 0-2000 ppm with accuracy of +/- 30 ppm.
      b. Manufacturers: Veris #CWE Series, Dwyer #CDT Series, or equal.
   2. Outdoor air measurement (indoor duct mounted location):
      a. Non-dispersive infrared sensor in high impact white ABS plastic enclosure. Input power 20 to 30 VDC/24 AC, 100 mA. Analog output 4-20 mA. Operating range 32°F to 122°F (0°C to 50°C). Measurement range of 0-2000 ppm with accuracy of +/- 30 ppm.
      b. Manufacturers: Veris #CDE Series, Dwyer #CDT Series, or equal.

E. CO2, Humidity, Temperature Combined Sensor (Indoor Wall and Duct Mounted)
   1. High impact white ABS plastic enclosure with digital LCD display and adjustable setpoints.
   2. Input power 20 to 30 VDC/24 AC, 100 mA.
   3. Analog output 4-20 mA.
   4. Operating range 32°F to 122°F (0°C to 50°C).
   6. Humidity Sensor: Digitally profiled thin-film capacitive, plus or minus 2% RH. 2% accuracy thin film capacitive replaceable sensor element, with weatherproof housing. 10K ohm, Type 2, or as required for controller interface. Two-wire, loop powered 4-20 mA.
7. Temperature Sensor: Thermistor. 2% accuracy thin film capacitive replaceable sensor element.
8. Manufacturers: Veris #CWLP Series or equal.

F. Air Filter Differential Pressure Gauges: (where not supplied by air handling equipment manufacturer):
1. Dial type, diaphragm-actuated with external zero adjustment and 3-7/8-inch diameter dial.
2. With two (2) static pressure tips, 2-way valves, tubing and mounting plate (and adjustable signal flag).
3. Range as recommended by filter manufacturer.
4. One gauge per filter bank for direct field verification independent of BAS monitoring.
5. Manufacturers: Dwyer 2000 Series Magnehelic or equal.

G. Current Sensors
1. Current sensing switch for constant speed fans and pumps to detect belt loss, coupling shear and mechanical failure:
   a. Current switch with split core, adjustable trip, pilot light, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Veris #HX08 Series or equal.
2. Current sensing switch for VFD controlling multiple fans and pumps:
   a. VFD current switch split core, self-learning adjustable trip, pilot light, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Veris #H614 or equal.
3. Current sensing switch with fixed trip point for monitoring constant speed direct-drive fans, recirculating pumps or other fixed loads:
   a. Current switch with split core, fixed trip, self-gripping split core housing and mounting bracket.
   b. Manufacturers: Veris #HX00 Series or equal.
4. Current sensing transmitter for load trending with proportional 4 to 20 mA output signal:
   a. Current sensing transmitter with self-gripping split core, preset slide switches, and removable mounting bracket.
   b. Manufacturers: Veris #H921 or equal.
5. Current sensing transmitter with relay for fan start/stop control and status monitoring of motors:
   a. Current sensing transmitter with integral relay, slide switches, self-gripping split core, and removable mounting bracket.
   b. Manufacturers: Veris #H931 or equal.

2.8 ACTUATORS

A. Electronic Actuators:
1. Size for torque required for damper seal at load conditions.
2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
3. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
4. Overload protected electronically throughout rotation.
5. Fail-Safe Operation: Mechanical, spring-return mechanism
6. Electronic Fail-Safe Operation: Incorporate a visual indication of the fail safe status on the face of the actuator. The power fail position shall be field adjustable between 0 to 100% in 10% increments. The electronic fail safe shall have a 2-10 second adjustable operational delay.
7. Power Requirements (Spring Return): 24-V ac, maximum 10 VA at 24-V ac or 8 W at 24-V dc (running). Maximum 1 VA at 24-V ac or 1 W at 24-V dc (holding).
8. Proportional Actuators shall be fully programmable through an onboard EEPROM by using an external cable and software interface.
9. Temperature Rating: -22 to +122°F.
11. Agency Listings: ISO 9001, cULus, CE or CSA
12. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
13. Manufacturers: Belimo or equal.

2.9 CONTROL VALVES

A. Manufacturer: Belimo, JCI or equal.

B. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional (except as noted).

C. Control Valve Actuators:
   1. Size for valve close off at 150 percent of total system (head) pressure for two-way valves; and 100 percent of pressure differential across the valve or 100 percent of total system (pump) head differential pressure for three-way valves.
   2. Coupling: directly couple and mount to valve stem, shaft ISO-style direct-coupled mounting pad.
   3. Non-spring return actuators shall have manual override.
   4. Spring return actuators of 90 inch-pounds or above shall have manual override.

D. Pressure Independent Control Valves:
   1. NPS 2 and Smaller: Forged brass body rated at no less than 400 PSI, chrome plated brass ball and stem, female NPT ends, dual EPDM lubricated O-rings and a brass or TEFZEL characterizing disc for equal percentage characteristic.
   2. NPS 2-1/2 through 6: GG25 cast iron body according to ANSI Class 125, standard class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring packing design, PTFE seats, and a stainless steel flow characterizing disc.
   3. The control valve assembly shall have an integral magnetic flow meter Magnetic flow meter to accurately control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSID across the valve with a valve body accuracy of +/- 5% variance due to differential pressure fluctuation or +/- 10% total assembly error incorporating differential pressure fluctuation, manufacturing tolerances and valve hysteresis.
   4. Flow Characteristics: NPS 1/2” through 2” Equal percentage characteristic. NPS 2-1/2” through 6” capable of Equal percentage or Linear characteristic (field programmable).
   5. All proportional actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
   6. Actuators for 3-wire floating (tri-state) and on 2 position (on/off) on 1/2” to 1” pressure independent control valves shall fail in place.
   7. Water Coil optimization 2-1/2” through 6” shall be accomplished by utilizing an energy meter (a pressure independent control valve assembly) with two integral temperature sensors providing feedback of coil inlet and coil outlet water temperature; and integral magnetic flow meter for control and to provide actual analog flow feedback. Valve assembly to have built in intelligence to control pressure independently and a Delta T Manager mode to mitigate low delta T syndrome by referencing an internally programmed design delta T setpoint. Valve assembly shall be capable of communicating data by means of BACnet MS/TP, BACnet I/P and TCP/IP. Data to include, but not be
limited to, inlet and outlet coil water temperatures, valve position, absolute flow, absolute valve position, absolute power and heating/cooling energy in BTU/hr. Valve assembly shall be capable of trending and storing up to 13 months of data on the actuator. T trended data on actuator to be retrievable via TCP IP or direct connect and download to *

8. The manufacturer shall provide a published commissioning procedure following the guidelines of the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC).

9. The control valve shall require no maintenance and shall not include replaceable cartridges.

10. NPS 2" and smaller pressure independent control valves for individual coil control shall be provided as part of a pipe package supplied by the valve manufacturer. The supply side of the coil shall contain an integrated isolation ball valve/manual air vent with strainer/shut-off valve/drain with pressure/temperature test ports. The return side shall contain a union fitting with a pressure/temperature test port, pressure independent control valve, and integrated isolation ball valve/manual air vent with a pressure/temperature test port. Shut-off valves as an integrated part of the pressure independent control valve are prohibited. A braided stainless flexible hose shall be provided for each coil supply and return connection for all pipe packages.

2.10 ENCLOSURES

A. All controllers, power supplies and relays shall be mounted in enclosures.

B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment.

C. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.

D. Outdoor enclosures shall be NEMA 3R or NEMA 4X, as necessary for the site.

E. Enclosures shall have hinged, locking doors.

F. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read.

PART 3 EXECUTION

3.1 EXAMINATION

A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this Section may properly commence.

B. Notify the Owner’s Representative in writing of conditions detrimental to the proper and timely completion of the work.

C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

A. Install in accordance with manufacturer’s instructions.
B. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum three (3) feet of clear access space in front of units. Obtain approval on locations from Owner’s Representative prior to installation.

B. Wall mounted temperature sensors will typically be mounted directly above or below light switches and comply with ADA height requirements. Coordinate with Owner, Architect and other trades to assure proper mounted locations prior to installation.

C. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.

D. Identify all equipment and panels. Provide permanently mounted tags for all panels.

E. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.4 CONDUIT

A. Conduit Requirements: all conduit shall with comply with minimum requirements of local authority having jurisdiction.
   1. Low voltage wiring in concealed areas may be plenum rated. Low voltage wiring in exposed areas shall be enclosed in conduit.
      a. All low voltage wiring exposed to weather shall be installed in conduit.
      b. Low voltage wiring in exposed areas, such as in mechanical, electrical, or service rooms, shall be installed in EMT conduit up to 10 feet above finished floor.
   2. All low voltage control wiring in critical facilities and critical locations shall be enclosed in conduit.

B. Provide rigid conduit for low voltage wiring in walls for all wall mounted sensors, CO2 sensors, humidity sensors, etc. Conduit shall be run to 6” (minimum) above the ceiling and shall terminate with a bushing installed on the conduit end. Flexible conduit shall not be used.

C. Provide conduit for low voltage wiring above inaccessible ceilings.

D. Conceal all conduits, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 12 inches (30 cm) from high-temperature equipment (i.e.- such as flues or high temperature pipes).

E. Conduit must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Conduit sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

F. Secure conduits with conduit clamps fastened to the structure and spaced according to code requirements. Conduits and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.
G. Size of conduit and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

3.5 LOW VOLTAGE INTERLOCKING AND CONTROL WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification, Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. All low-voltage wiring shall meet NFPA-70 (NEC) Article 725 Class 2 requirements. Low-voltage power circuits shall be subfused when required to meet Class 2 current limit.

C. Do not install Class 2 wiring (greater than 100 volts and protected by overcurrent device not over 20 amperes) in conduits containing Class 1 wiring (not exceeding 30 volts and 1000 volt-amperes). Boxes and panels containing line voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

D. Unless otherwise noted, power wiring for all valve and damper actuators is Class 2. If the BAS contractor desires to substitute 120-volt actuators, the BAS contractor shall coordinate directly with the General Contractor and Electrical Contractor to provide all 120-volt wiring and conduit at no additional cost to the Owner.

E. Contractor shall provide step-down transformers as necessary.

F. Install insulated bushings on all conduit ends and openings to enclosures. Seal top end of vertical conduits.

G. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block. Wire nuts are not acceptable.

H. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

I. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

J. Use color-coded conductors throughout with conductors of different colors.

K. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

L. The contractor shall terminate all communications, control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

3.6 COMMUNICATION WIRING

A. The contractor shall adhere to the wiring requirement previously listed.

B. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer’s installation recommendations for all communication cabling.
C. Do not install communication wiring in conduits and enclosures containing Class 1 or other Class 2 wiring.

D. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

E. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

F. When a cable enters or exits a building, a lightning arrester must be installed between the lines and ground. The lighting arrester shall be installed according to manufacturer’s instructions.

G. All runs of communication wiring shall be unspliced length when that length is commercially available.

H. All communication wiring shall be labeled to indicate origination and destination data.

I. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

J. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:
   1. The network shall use shielded, twisted-pair or stranded cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot). Wire gauge and wire type shall be sized and coordinated with manufacturer load requirements and lengths of runs.
   2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
   3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
   4. An MS/TP EIA-485 network shall have no T connections.

K. All Ethernet cabling, routers, hubs and switches for connecting 230900 furnished and installed control panels, servers and clients to the building Owner's Ethernet network are the responsibility of the BAS contractor.

3.7 MOTORIZED DAMPERS

A. Where ducts penetrate an exterior surface install a Class I motorized damper at each outdoor air supply opening, return air opening, exhaust opening, relief outlet, shaft vent and stairway vent, as required to comply with minimum requirements of the local Energy Code.
   1. Dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback operation, unless the system served requires outdoor air or exhaust air or operates continuously or the dampers are opened to provide intentional economizer cooling.
   2. Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building's fire alarm system or the interruption of power to the damper.

3.8 FIELD SERVICES

A. Prepare and start logic control system under provisions of this section.
B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation. Provide all labor and services as necessary to support testing and verification by third party commissioning authority.

C. Provide the capability for off-site monitoring at control contractor’s local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one year or as specified.

D. Provide Owner’s Representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.

3.9 PROJECT RECORD DOCUMENTS

A. Project Record Documents: Upon completion of installation, submit three copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and shall include:
   1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2006 (or newer) compatible files on optical media and as 11” x 17” prints.
   2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Part 3: “Control System Demonstration and Acceptance.”
   4. As-built versions of submittal product data.
   5. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
   6. Operator’s manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
   7. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
   8. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
   9. Documentation of all programs created using custom programming language including setpoints, tuning parameters, and object database.
   10. Graphic files, programs, and database on magnetic or optical media.
   11. List of recommended parts with part numbers and suppliers.
   12. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
   13. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
   14. Licenses, guarantees, and warranty documents for equipment and systems.
   15. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

3.10 TRAINING

A. Provide application engineer to instruct Owner in operation of systems and equipment.

B. Provide system operator’s training to include (but not be limited to) such items as the following: modification of data displays, alarm and status descriptors, requesting data,
execution of commands and request of logs. Provide this training to a minimum of three persons.

C. Provide on-site training above as required, up to 16 hours as part of this contract.

D. Provide tuition for at least one individual to attend for a one-week factory training class. If applicable, costs for travel, lodging and meals will be the responsibility of the Owner.

3.11 DEMONSTRATION

A. Demonstrate complete operating system to Owner’s Representative.

B. Provide certificate stating that control system has been tested and adjusted for proper operation.

END OF SECTION
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. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. Related Sections include the following:
   1. Section 230900 "Building Automation System (BAS) Controls " for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

A. BAS: Building Automation System

B. DDC: Direct digital control.

C. VAV: Variable air volume

D. VFD: Variable frequency drive.

1.4 ABBREVIATIONS

A. The following abbreviations may be used in graphics, schematics, point names, and other applications where space is at a premium.
   1. AC - Air Conditioning
   2. ACU - Air Conditioning Unit
   3. AHU - Air Handling Unit
   4. AI - Analog Input
   5. AO - Analog Output
   6. AUTO – Automatic
   7. AUX – Auxiliary
   8. BI -Binary Input
   9. BO -Binary Output
   10. C –Common
   11. CHW - Chilled Water
   12. CHWP - Chilled Water Pump
   13. CHWR - Chilled Water Return
   14. CHWS - Chilled Water Supply
   15. COND – Condenser
   16. CW - Condenser Water
   17. CWP - Condenser Water Pump
   18. CWR - Condenser Water Return
   19. CWS - Condenser Water Supply
   20. DA - Discharge Air
   21. EA - Exhaust Air
   22. EF - Exhaust Fan
   23. EVAP – Evaporators
   24. FCU - Fan Coil Unit
25. HOA - Hand / Off / Auto
26. HP - Heat Pump
27. HRU - Heat Recovery Unit
28. HTEX - Heat Exchanger
29. HW - Domestic Hot Water
30. HWC - Domestic Hot Water Recirculation
31. HWP - Heating Water Pump
32. HWR - Heating Water Return
33. HWS - Heating Water Supply
34. MAX - Maximum
35. MIN - Minimum
36. MISC - Miscellaneous
37. NC - Normally Closed
38. NO - Normally Open
39. OA - Outdoor Air
40. RA - Return Air
41. RF - Return Fan
42. RH - Relative Humidity
43. RTU - Roof-top Unit
44. SA - Supply Air
45. SF - Supply Fan
46. SP - Static Pressure
47. TEMP - Temperature
48. UH - Unit Heater
49. UV - Unit Ventilator
50. VAV - Variable Air Volume
51. VVTU - Variable Volume Terminal Unit
52. W/ - with
53. W/O - without
54. WSHP - Water Source Heat Pump

1.5 BACNET COMMUNICATIONS INTERFACE

A. For all equipment designated with a BACnet communication interface module, the controls contractor shall review the sequence of operation identified below and coordinate with each approved equipment manufacturer to provide the designated points either through the interface or a hard wire connection (at no additional cost) where capability is not available through interface.

B. The controls contractor shall identify points to be either commanded, trended or monitored through the interface. At a minimum, the BAS shall have capability to access the following functions for the system and all subequipment: system enable, equipment enable, status, alarm, temperature, pressure, reset signals, maintenance alarm, operation mode, run time, firing/input rate, set point adjustment, delay and scheduling.

C. The controls contractor shall coordinate with each approved equipment manufacturer to provide a full list of available points available through the interface. All functions to be mapped through the interface should be submitted for engineer approval.

1.6 TRIM AND RESPOND RESET LOGIC

A. Definitions:
   1. $SP_0$ - Initial set point
   2. $SP_{\text{min}}$ – Minimum set point
3. $SP_{max}$ – Maximum set point
4. $T_d$ - Delay timer
5. $T$ – Time step
6. I – Number of ignored requests
7. $R$ – Number of requests from zones/systems
8. $SP_{trim}$ – Trim amount
9. $SP_{res}$ – Respond amount
10. $SP_{res-max}$ – Maximum response per time interval

B. Controls contractor shall provide trim and respond reset logic as follows:
   1. Controls contractor shall provide trim and respond reset logic as noted below in sequence of operation. Trim and respond logic shall reset set point within the range of $SP_{min}$ to $SP_{max}$ until zones request a response.
   2. The reset logic shall be active while the associated device is proven on, starting $T_d$ after initial device start command. When active, every time set $T$, trim the set point by $SP_{trim}$. If there are more than I requests, respond by changing the set point by $SP_{res}$ times ($R-I$). But the net response shall be no more $SP_{res-max}$. The sign of $SP_{trim}$ must be the opposite of $SP_{res}$ and $SP_{res-max}$. Controller shall keep trimming the set point until zones requests a response.
   3. The control loop shall be tuned based on the field conditions. Typical startup conditions are as follows:
      a. Requests: If the loop is less than 85%, send 0 requests. If the loop is greater than 95%, send 1 request.
      b. Importance Multiplies: Multiply zones requests by IM, Default value IM=1. Allow rogue zones to be ignored (IM=0). Identify integral of requests hour time to identify rogue zones.

PART 2 PRODUCTS (Not Applicable – Refer to 230900)

PART 3 EXECUTION

3.1 VARIABLE AIR VOLUME SERIES FAN POWERED TERMINAL UNIT – HEATING WATER REHEAT WITHOUT CARBON DIOXIDE (CO2) MONITORING

A. Features
   1. Primary cooling damper and actuator
   2. Heating water reheat coil
   3. Chilled water coil
   4. Variable speed fan
   5. All setpoints shall be user adjustable

B. Run Conditions - Scheduled: The unit shall run according to a user definable time schedule and maintain the following modes:
   1. Occupied Mode Temperatures:
      a. Cooling setpoint - 75°F
      b. Heating setpoint - 70°F
   2. Unoccupied Mode Temperatures (night setback): 
      a. Cooling setpoint - 85°F
      b. Heating setpoint - 55°F
   3. Four primary air intake airflow control setpoints shall apply as follows:
      a. Occupied cooling maximum air flow as scheduled
      b. Occupied heating maximum air flow as scheduled
      c. Unoccupied cooling/heating minimum air flow as scheduled
4. Four terminal total airflow control setpoint shall apply as follows:
   a. Occupied cooling maximum terminal air flow as scheduled
   b. Occupied heating maximum terminal air flow as scheduled
   c. Unoccupied cooling/heating terminal minimum air flow as scheduled

5. Alarms shall be provided as follows:
   a. High Zone Temp: If the zone temperature is 5°F greater than the cooling setpoint.
   b. Low Zone Temp: If the zone temperature is 5°F less than the heating setpoint.

C. Air Flow Control: The unit shall maintain zone setpoints by controlling the airflow through one of the following:
   1. Occupied:
      a. When zone temperature is greater than its cooling setpoint, the zone temperature will be utilized by central BAS to modulate both terminal air volume from setpoint through the deadband to full flow at deadband offset. During this modulation the primary air valve will also modulate open to deliver the maximum cooling air supply at the lowest supply temperature based on system demands.
      b. At setpoint the terminal airflow will be at minimum airflow. As space temperature moves through deadband so that zone temperature is less than its heating setpoint, the terminal air volume is increased with primary air at minimum. When terminal air volume is maximum modulate the reheat valve to reheat the combination of recirculated and primary air to bring the space into control.
   2. Unoccupied:
      a. When the zone is unoccupied the zone primary damper shall control to its minimum unoccupied airflow or shall be closed.
      b. When the zone temperature is greater than its cooling setpoint, the zone damper shall modulate to the maximum cooling airflow until the zone is satisfied.
      c. When zone temperature is less than its heating setpoint, the zone damper shall modulate to the maximum airflow and the BAS shall modulate the reheat control valve to maintain the zone temperature at its heating setpoint. The zone damper and reheat control valve shall operate to provide maximum heating airflow until the zone is satisfied.

D. Reheating Coil Valve: The BAS shall measure the zone temperature and modulate the reheating coil valve open on dropping temperature to maintain its heating setpoint. The reheat coil control valve shall fail in the last position (non-spring return).

E. Chilled Water Coil Valve: The BAS shall measure the zone temperature and modulate the chilled water coil valve open on rising temperature to maintain its cooling setpoint. This shall operate in conjunction with the airflow reset strategy. The cooling coil control valve shall fail in the last position (non-spring return).

F. Reheating - High Discharge Air Temperature Limit: The BAS shall measure the discharge air temperature and limit reheating if the discharge air temperature is more than 25°F above the zone temperature.

G. Chilled Water Condensation Alarm: The BAS shall monitor the pipe condensation sensor and limit cooling if the sensor indicates moisture on the pipe. In this condition, the primary air shall modulate to maximum to dehumidify the space until the condensation alarm is no longer active and shall slowly reduce to primary air setpoint.

H. Discharge Air Temperature: The BAS shall monitor the discharge air temperature.
   1. Alarms shall be provided as follows:
      a. High Discharge Air Temperature: If the discharge air temperature is greater than 120°F.
b. Low Discharge Air Temperature: If the discharge air temperature is less than 40°F.

I. Occupancy Sensor Operation (where equipped):
   1. When space is occupied the terminal unit control sequence shall function as previously stated for the occupied mode.
   2. When space is unoccupied the terminal unit control sequence shall function as previously stated for unoccupied mode.

3.2 EXHAUST FAN - ON/OFF (various applications)

   A. Run Conditions - Interlocked: The fan(s) shall be interlocked to run whenever the local switch is turned on/off or if the current sensor indicates the associated equipment or multiple pieces of equipment is in use.

   B. Fan Status: The BAS shall monitor the fan status.
      1. Alarms shall be provided as follows:
         a. Fan Failure: Commanded on, but the status is off.
         b. Fan in Hand: Commanded off, but the status is on.

   C. Motorized Damper:
      1. BAS shall open associated motorized damper prior to turning on the fan and close the damper after the fan is shutdown.
      2. BAS shall monitor damper position
      3. Alarms shall be provided as follows:
         a. Damper Failure: Commanded open, but the status is closed.
         b. Damper in Hand: Commanded closed, but the status is open.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this section shall include, but not necessarily be limited to, the following:
   1. Pipe and Fittings:
      a. Chilled water piping aboveground
      b. Heating water piping aboveground
   2. Valves:
      a. HVAC Service Valves (125 psig max. working pressure)
      b. Check Valves
      c. Balancing Valves (125 psig working pressure)
      d. Combination HVAC terminal unit valve line sets
   3. Piping specialties:
      a. Thermometers
      b. Pressure gauges
      c. Expansion Compensators
      d. Pipe escutcheons
      e. Strainers
      f. Drip pans
      g. Air vent
      h. Air elimination valves
      i. Dielectric unions and flanges
      j. Unions
      k. Flanges
      l. Pipe sleeves
      m. Sleeve seals
      n. Valve boxes
      o. Pipe coating

B. In addition, provide the following:
   1. Furnish accessories and labor for flushing and cleaning HVAC piping.
   2. Install water treatment systems.
   3. Furnish material, accessories and labor for glycol antifreeze charging of new HVAC piping.

C. Condensate disposal drainage piping is required per the applicable mechanical code. Reference Division 22 for additional condensate drainage piping.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Division 01: General Requirements.

B. Division 22: Plumbing.
C. Division 23: Mechanical.
   1. Section 230500: Basic HVAC Materials and Methods.
   2. Section 230548: Vibration Isolation for Piping Ductwork and Equipment.
   5. Section 230719: HVAC Piping Insulation.
   7. Section 232123: Hydronic Pumps.
   8. Section 232500: HVAC Water Treatment.
  10. Section 235216: Condensing Boilers.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Manufactured items furnished shall be the current, cataloged product of the manufacturer.
   2. Replacement parts shall be readily available and stocked in the USA.

B. Codes and Standards:
   1. All work shall be in full accordance with all applicable codes, ordinances and code rulings.
   2. The Contractor shall furnish without any extra charge the labor and material required for compliance of codes.
   3. Perform all tests required by governing authorities and as required under all Division 23 Sections. Provide written reports on all tests.
   4. Electrical devices and wiring shall confirm to the latest standards of NEC; all devices shall be UL listed and so identified.
   5. All HVAC work shall comply with the Americans with Disabilities Act (ADA).
   6. All excavation work must comply with all provisions of state laws including notification to all owners of underground utilities at least 48 business day hours, but not more than 10 business days, before commencing an excavation.

C. Product Control
   1. Protection: Use all means necessary to protect materials before, during, and after installation and to protect the installed work and materials of all other trades.
   2. The general arrangement and locations of piping are shown on the Drawings. Changes may be necessary to accommodate work. If project conditions require deviations from arrangement or location indicated to meet existing conditions or due to interference with work of other trades, such deviations as offsets, rises and drops in piping that may be necessary, whether shown or not, shall be made without extra expense. Accuracy of data given herein and on the Drawings is not guaranteed. The Drawings and Specifications are for assistance and guidance, and exact locations, distances, and elevations will be governed by actual site conditions.
   3. All work shall be in accordance with the applicable codes listed in Division 01. No extra charge will be paid for furnishing items required by the regulations but not specified herein or shown on the Drawings. Should there be any direct conflict between the Drawings and/or Specifications and the above rules and regulations, the rules and regulations shall take precedence.
   4. All work shall be completely coordinated, and all lines, grades, slopes and vertical and horizontal locations of pipes shall be exactly determined in the field and cleared with the Owner's Representative before the installation of these items is begun. No extra compensation shall be made for failure to observe this clause.
5. The Drawings and Specifications do not undertake to list every item that will be installed. When an item is necessary for the satisfactory operation of the system, it shall be furnished without extra cost. Work called for in the Specifications, but not on the Drawings, or vice versa, shall be done as though required by both. Lack of specific mention of any work necessary for proper completion of the work in the Specifications and/or Drawings, shall not lessen the Contractor's responsibility.

6. Obtain Owner's Representative's approval prior to rerouting of existing services. Refer to Division 01 sections for alterations, shutdown and temporary construction for existing services.

7. Pipe spaces provided in the design shall be utilized and the work shall be kept within the spaces established on the Drawings.

8. Manufacturers' directions shall be followed in all cases where manufacturers of articles used in this Contract furnish directions covering points not shown on the Drawings or specified herein. Manufacturers' directions do not take precedence over the Drawings and Specifications. Where manufacturers' directions conflict with the Drawings and Specifications, submit these conflicts to the Owner's Representative and receive clarification before installing the work.

9. Do not permit or cause any work to be covered or enclosed until it has been inspected, tested, and approved. Should any of the work be enclosed or covered before inspection and test, Contractor shall, at his/her own expense, uncover the work; and, after it has been inspected, tested and approved, make all repairs with such materials as may be required. Restore all work to its original and proper condition.

10. Be responsible for damage to any of this work before acceptance. Securely cover all openings, both before and after setting into place, to prevent obstructions in the pipes and breakage.

11. Repair all damage to the premises occasioned by the work. All damage to any part of the premises caused by leaks or breaks in the pipe installed under this Section of the work for a period of one (1) year after date of final acceptance of the work, shall be repaired.

D. All materials (such as insulation, ductwork, piping, wiring, controls, etc.) located within air plenum spaces, air shafts, and occupied spaces shall have a flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing, or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those specified.

E. Welding Standards:
1. Welding Qualifications:
   a. Certification: Each welder shall have a current AWS QC7 welding certification with successful completion of written test and welding samples in compliance with AWS D1.1. The welder must maintain their certification to show qualified welding experience every six months. The Owner’s Representative reserves the right to request sample coupon test welds of each welder to validate quality of welding work.

2. Welding Procedures:
   a. Steel Support Welding: All work shall be performed in compliance with American Welding Society AWS D1.1/D1.1M-Structural Welding Code-Steel.
   b. Pipe Welding: All work shall be performed to meet or exceed the requirements of the American Welding Society AWS B2.1 Specification for Welding Procedure and Performance Qualification and ASME Boiler & Pressure Vessel Code: Section IX “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.”
F. Pressure Piping Standards
   1. Comply with ASME B31.1 Power Piping, ASME B31.3-Process Piping and ASME B31.9-
      Building Services Piping standards for materials, products, and installation per pressure
      and temperature operating class.
   2. Comply with ASME B31.9 Building Services Piping standard for the following services:
      a. Conveying fluid between 0°F (-18°C) to 250°F (121°C).
      b. Fluid pressure less than 350 psig.
   3. Comply with ASME B31.3 Process Piping standard for the following services:
      a. Conveying fluid above 250°F (121°C).
      b. Toxic or flammable fluids.

1.5 DEFINITIONS
   A. ECM: Electronically commutated motor.
   B. EPDM: Ethylene propylene diene monomer.
   C. EPR: Ethylene propylene rubber.
   D. FKM: Fluoroelastomer polymer.
   E. HI: Hydraulic Institute.
   F. NBR: Nitrile rubber or Buna-N.

1.6 SUBMITTALS
   A. Product Data: Submit manufacturer’s technical product data for all piping, valves and
      specialties indicating dimensions, valve CV, flow capacity, pressure setting, tolerances etc.
   B. Maintenance Data: Submit maintenance instructions, including instructions for lubrication,
      valve replacement, and spare parts lists. Include this data, product data, and shop drawings
      in operating and maintenance manuals.
   C. Grooved joint couplings and fittings shall be shown on drawings and product submittals and be
      specifically identified with the applicable mechanical coupling style number.
   D. Delegated-Design Submittal for each vibration isolation, expansion joint and seismic-restraint
      device.
      1. Seismic restraint calculations must be provided for all connections to the structure.
      2. Include design calculations and details for selecting vibration isolators, seismic restraints,
         and vibration isolation bases complying with performance requirements, design criteria,
         and analysis data signed and sealed by the qualified professional engineer responsible
         for their preparation.
      3. 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 that riser system was
         examined for excessive stress and that none exists.
      4. Provide flexible joints, supports and piping joints as required to accommodate movement
         across seismic expansion joints and vertical building drift between floors.
      5. Design: Design and calculate requirements for thermal expansion of piping systems and
         for selecting and designing expansion joints and loops.
6. Anchor Details: Detail fabrication of each anchor. Show dimensions and methods of assembly and attachment to building structure. Supports, anchors, and guides shall be designed for combined gravity, seismic, pressure, and thermal loads.

7. Alignment Guide Details: Detail field assembly and attachment to building structure.

8. Schedules: Each expansion joint/expansion loop shall be scheduled with manufacturer, type, material, size, pressure rating, end connections, and location.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver unit to the site in containers with manufacturer’s stamp or label affixed.

B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

C. Provide the following additional extended warranty requirements that apply to piping with mechanical type joints and fittings, such as grooved or pressed/compression type fittings.

1. The warranties and corrective obligations provided under this section: (i) are in addition to, and not in lieu of, any other warranty, representation, covenant, duty or other obligation (including any corrective obligation) of the Contractor or Manufacturer; (ii) have no relationship to the time when any warranty, representation, duty, covenant or other obligation of Contractor or Manufacturer may be enforced or any dispute resolution proceeding commenced; and (iii) are made by the Manufacturer to both the Contractor and the Owner and by the Contractor to Owner.

2. Contractor and Manufacturer warrant that, for a period of ten (10) years from the date of Substantial Completion, the entire system, including but not limited to the fittings and joints, will conform to the requirements of the Contract Documents, will be free from defects, and will not leak.

3. Nothing in any separate warranty or other document provided by Contractor or Manufacturer, or both, will apply to limit their liability or responsibility for damages arising out of or related to a breach of any warranty or corrective obligation.

PART 2 PRODUCTS

2.1 GENERAL

A. Furnish and install all new material, equipment, and apparatus hereinafter specified unless specifically noted otherwise. All material, equipment, and apparatus shall be identified by the manufacturer's name, nameplate, and pertinent data.

1. All pipe, pipe fittings and valves shall be manufactured in North America. Alternatives may be acceptable, but must be submitted and approved by the Owner’s Representative prior to bidding.

B. Type M copper piping is not acceptable for any pressure water piping unless specifically noted otherwise.
C. All materials, equipment, and apparatus are mentioned as standards unless noted otherwise. The words "or approved equal" shall be considered to be subsequent to all manufacturers’ names used herein, unless specifically noted that substitutes are not allowed.

D. Hydronic Piping Pressure Classifications:
   1. Chilled Water, Condenser Water and Heating Water:
      a. "Normal Pressure" shall be working fluid pressure up to 125 psig.

2.2 PIPE AND FITTINGS

A. Chilled Water Piping: (Aboveground)
   1. Steel Pipe:
      a. Pipe Material: ASTM A53 Grade B, Schedule 40 black steel up to 10” diameter. Standard weight black steel for 12” and larger.
      b. Fittings:
         1) Steel normal pressure application: 150 lb. rating. ANSI B16.3, malleable iron threaded for pipe 2-inch and under; ANSI B16.5, flanged; ANSI B16.9, steel bevel welding
   2. Copper Tubing:
      a. Pipe Material: ASTM B88, Type K or Type L hard drawn copper water tube for normal pressure aboveground.
      b. Fittings:
         1) ASME B16.23 cast brass or ANSI/ASME B16.22 wrought copper with the following connection methods.
         2) Soldered or brazed: ASTM B32, solder, Grade 95TA.
            (a) 2” and smaller: Make connections using 95%-5% tin-antimony solder joints aboveground or sil-fos brazing.
            (b) 2-1/2” and larger: Sil-Fos brazing or flanged.

B. Heating Water Piping (Aboveground):
   1. Steel Pipe: ASTM A53 Grade B, Schedule 40 black steel up to 10” diameter, and Std. Wt. Black steel for 12” diameter and greater.
      a. Fittings:
         1) Steel normal pressure application: 150 lb. rating. ANSI B16.3, malleable iron threaded; ANSI B16.5, flanged; ANSI B16.9, steel bevel welding
         2) Steel high-pressure application: 300 lb. rating. ANSI B16.3, malleable iron threaded; ANSI B16.5, flanges; ANSI B16.9, steel bevel welding.
   2. Copper: ASTM B88, Type K or Type L hard drawn copper water tube for normal pressure aboveground.
      a. Fittings:
         1) Copper system: ANSI B16.22, wrought copper with the following connection methods.
            (a) 2” and smaller: Make connections using 95%-5% tin-antimony solder joints or sil-fos brazing.
            (b) 2-1/2” and larger: Sil-Fos brazing or flanged.

C. Temperature and Pressure Relief Valve Discharge Piping:
   1. Hydronic Water System (150 psig and 212 deg. F. maximum):
      a. Pipe: Type M or L copper ASTM B88
      b. Pipe: Schedule 40 black steel, ASTM A53 Grade B.
      e. Joints: ANSI B16.22, wrought copper, with 95%-5% tin-antimony solder joints.
f. Joints: 2” and smaller, threaded (except in the case of piping located in shafts which must be welded); 2-1/2” and larger, ANSI B16.25 bevel weld, ANSI B16.5 flanges, or ANSI B16.11 socket weld.

2.3 VALVES-GENERAL

A. General: Valve ratings shall exceed respective system operating pressures by 50% (minimum). All valves shall be line size unless otherwise noted.

B. Product Data: Submit manufacturer’s technical product data, including installation instructions for each type of valve. Include pressure drop curve or chart for each type and size of balancing valve or circuit setter. Submit valve schedule showing manufacturer’s figure number, size, location, and valve features for each required valve.

C. Shop Drawings: Submit manufacturer’s assembly-type (exploded view) shop drawings for each type of valve, indicating dimensions, weights, materials, and methods of assembly of components.

D. Acceptable Manufacturers (manufacturer and model number listed for individual valves indicates minimum acceptable by all manufacturers):
   5. Hydronic Pressure Relief Valves: Cash-Acme, Cla-Val, Watts, Wilkins, or equal.
   6. Hydronic Balancing Valves and Circuit Setters: Pro Hydronic Specialties, Griswold (Venturi with characterized ball valve only), Wheatley (Y-globe type only), Armstrong, Nibco (globe style), Victaulic/Tour & Anderson, Bray, Anvil-Gruvlok, Oventrop, Tyco-Grinnell, or equal.

E. Valve Identification: Provide valves with manufacturer’s name (or trademark) and pressure rating clearly marked on the valve body.

F. Operators:
   1. Provide 90-degree lever operator for ball valves.
   2. Provide 90-degree locking lever operator for butterfly valves up through 5” size. For 6” size and greater, provide gear operator and handwheel.
   3. Provide insulated valve stem extension for lever-operated valves on insulated piping, so handle will clear insulation and jacket. Provide valve manufacturer’s plastic insulated housing where available as valve option.
   4. Provide chain operated sheaves on valves sizes 2-1/2” and larger, located more than ten (10) feet from floor in equipment room areas. Provide chain and extend down to five (5) feet above floor and hook clips on chain arranged to clear walking aisles.

G. Valve Features:
   1. General: Provide valves with features indicated and, where not otherwise indicated, provide proper valve features. Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.
   2. Bypass: On valves 6” and larger comply with MSS SP-45, and except as otherwise indicated, provide manufacturer’s standard bypass piping and valving. Provide a 3-valve
bypass, minimum 1" size, to consist of two threaded shut-off valves and a plugged drain valve.

3. Drain: Comply with MSS SP-45 and provide 3/4" threaded pipe end with cap and chain.


5. Grooved: Valves shall be joined using grooved joint couplings of the same manufacturer. Copper tubing valve grooved ends shall be copper tubing sized.


8. Disks: Butterfly valve disc may be stainless steel, bronze, nickel plated ductile iron or aluminum bronze for hydronic service. Coated discs may only be considered for corrosive fluid service.


10. Flangeless: Valve bodies manufactured to fit between flanges complying with ANSI B16.1 (cast iron), ANSI B16.5 (steel), or ANSI B16.24 (bronze).

2.4 HVAC SERVICE VALVES (MAXIMUM 125 PSIG SYSTEM WORKING PRESSURE)

A. Ball Valves, 2" and Smaller:

1. 2-piece bronze body, 600 psi rating, stainless steel or chrome plated brass ball, Teflon seat, brass or stainless steel stem, steel handle, full port. Threaded steel ends for iron pipe and soldered ends for copper pipe. Threaded steel pipe: Milwaukee #BA-400 or equal. Soldered copper pipe: Milwaukee #BA-450 or equal.

2. 3-piece carbon steel body, 1000 psig WOG rating up to 300°F, MSS SP-110 compliant, threaded ends, stainless steel ball, stainless steel stem, reinforced PTFE seat, stainless steel lever handle, full port. Manufacturers: Milwaukee #30CSOF02, Keystone #K-ball Figure 120, or equal.

3. 3-piece stainless steel body, 400 psi maximum operating pressure, ASTM A-351 compliant, Vic-Press Schedule 10S ends or grooved for Type 304 stainless steel pipe, stainless steel body, stainless steel ball, stainless steel stem, PTFE seats, stainless steel handle, full port. Manufacturers: Victaulic #Series P569 or equal.

B. Butterfly Valves, 2-1/2" and Larger:

1. 2-1/2" through 12", lug type, MSS SP-67 compliant, working pressure to 200 psig non-shock, cast or ductile iron body, stainless steel stem, EPDM seat, memory stop control, lever handle thru 5" size and worm gear operator for 6" and larger. Disc may be stainless steel, bronze, nickel plated ductile iron or aluminum bronze. Molded in seat acceptable in this size range. Manufacturers: Milwaukee #ML223E (up to 5"), Milwaukee #ML323E (6" and larger), Keystone (Emerson) #222 or equal.

2. 14" through 48", lug type, MSS SP-67 compliant, working pressure to 150 psig non-shock, ductile iron body, stainless steel stem, EPDM seat, memory stop control, worm gear operator. Disc may be stainless steel, bronze, nickel plated ductile iron or aluminum bronze. Manufacturers: Milwaukee #ML333E, Keystone #GRL, or equal.

3. 2-1/2" through 12" grooved end type, MSS SP-67 compliant, working pressure to 300 psig, ASTM A395 and A536 compliant, ductile iron body, EPDM seal, stainless steel stem, and memory stop control. Lever handle thru 5" size and worm gear operator for 6" and larger. Disc may be nickel plated ductile iron, aluminum bronze or stainless steel. Manufacturers: Victaulic #Series 761 Vic®-300 MasterSeal, Milwaukee #UPGG-245E/345E, Milwaukee #HP3L Series, Tyco-Grinnell #B302, Gruvlok #FIG 7700 Series, or equal.

4. 14" through 24" grooved end type, MSS SP-67 compliant, working pressure to 300 psig, ASTM A395 and A536 compliant, ductile iron body, EPDM seal, stainless steel stem, with gear operator. Disc may be nickel plated ductile iron, aluminum bronze or stainless steel.
Manufacturers: Victaulic #Series 761 Vic®-300 AGS (300 psi maximum pressure.), Milwaukee #HP3L Series, Tyco-Grinnell # FIG 7700 series, or equal.

5. 2-1/2" through 6" copper tube dimensioned grooved end type, cast brass body, EPDM seal, working pressure to 300 psig, stainless steel stem, memory stop control, lever handle thru 5" size and worm gear operator for 6". Disc may be nickel plated ductile iron, aluminum bronze or stainless steel. Manufacturers: Victaulic #Series 608N, Tyco-Grinnell #B680, Gruvlok #BFV, or equal.

C. Check Valves:
1. Bronze Silent Check Valves – Up to 2" for mounting in close proximity to pumps:
   a. Class 125, MSS SP-80, ASTM B62, ASTM B16, bronze body, threaded ends, bronze or stainless steel spring, PTFE or Buna disk ring, and silent closing. Manufacturers: Milwaukee #548B (Buna)/548T (PTFE) or equal.
2. Bronze T-Pattern Swing Check Valves – Up to 3" for horizontal mounting adjacent to air handling units and fan coils:
3. Globe Style Silent Check Valves – 2-1/2" and Larger:
   a. Class 125, MSS SP-125, ASTM A126 class B cast iron body, SS seat and plug, stainless steel spring, SS bushing, stainless screw. ANSI B16.1 flange rating to 190 psi up to 12" and 135 psi above 12". Manufacturers: Milwaukee #1800, Cla-Val #Series 581, Apco #Series 600, Metraflex #Series CVO900 or equal.
4. Wafer Style Silent Check Valves – 2" and Larger:
   a. Class 125, MSS SP-125, ASTM A126 class B cast iron body, stainless steel seat and disc, stainless steel spring, SS bushing, stainless screw. ANSI B16.1 flange rating to 190 psi up to 12" and 135 psi above 12". Manufacturers: Milwaukee #1400 single disk, Milwaukee #8800 dual disk, Prince #Fig. 810, US Valve #Series 09, or equal.
5. Grooved Style Silent Check Valves – 2" to 12":
   a. ASTM A536 ductile iron body, single stainless steel disc, EPDM disc coating, brass or stainless steel shaft, stainless steel spring, stainless steel plug. Sizes 2" to 3" rated for 365 psi working pressure and sizes 4" to 12" rated for 300 psi working pressure. Manufacturers: Victaulic #Series 716H/716, Anvil-Gruvlok #Series 7800, Tyco-Grinnell #Series 590 or equal.
   b. Venturi style check valve with flow measuring taps across the valve. ASTM A536 ductile iron body, single stainless steel disc, EPDM disc coating, brass or stainless steel shaft, stainless steel spring, stainless steel plug. Sizes 2" to 3" rated for 365 psi working pressure and sizes 4" to 12" rated for 300 psi working pressure. Manufacturers: Victaulic #Series 779 or equal.

D. Drain Valves:
1. Threaded or soldered ends, Class 125, ASSE 1005, bronze body, screw-in bonnet, rising stem, composition disc, 3/4" hose outlet.
2. Threaded or soldered ends, Class 600, bronze body, 2-piece ball valve, 3/4" hose outlet with cap and chain. Manufacturers: Milwaukee #BA-100H/150H or equal.

E. Globe Valves:
1. 2" and Smaller: Class 150, MSS SP-80 and ASTM B62 compliant cast bronze body, bronze union bonnet, PTFE disc, rising stem, brass packing gland, non-asbestos packing and aluminum or malleable iron hand-wheel. Manufacturers: Milwaukee #590T or equal for threaded steel pipe. Milwaukee #1590T or equal for soldered copper pipe.
2. 2-1/2" and Larger: Class 125, MSS SP-70, ASTM A126 Grade B cast iron body, flanged ends, bolted bonnet and disc, bronze trim, OS & Y, brass packing gland, non-asbestos packing and cast iron hand-wheel. Manufacturers: Milwaukee #F-2981-M or equal.
2.5 BALANCING VALVES (MAXIMUM 125 PSIG SYSTEM WORKING PRESSURE)

A. Pressure Independent Water Flow in Variable Flow Systems:
   1. 1/2" and Larger: Construction and attachment style as required by piping system. Body shall be brass, bronze, steel or ductile iron as required by valve size. Internal working parts and removable flow cartridge shall be stainless steel. Valves shall be factory set and shall automatically limit the flow to specified capacities with 10% +/- accuracy over the entire operating pressure differential. Pressure and temperature ports shall be extended to outside of insulation. The permanent pressure lost added to the pump head shall not exceed three (3) psi.

B. Pressure Dependent Water Flow in Constant Flow Systems:
   1. 1/2" and Larger: Construction and attachment style as required by piping system. Body shall be brass, bronze, steel or ductile iron as required by valve size. Characterized ball valve or Y-type globe valve design with memory stop. Valves shall be field adjustable. Pressure and temperature ports shall be extended to outside of insulation. Install in pipe with minimum length of unrestricted straight pipe equivalent to five pipe diameters upstream and two pipe diameters downstream.
   2. Manufacturers: Pro Hydronic Specialties #CBV, Hays Fluid Controls Venturi (insert/ball valve style), Preso Venturi #B-Plus series, Oventrop Hydrocontrol #R,F, and G, Griswold (Venturi with characterized ball valve only), IMI Flow Design #FlowSet, Wheatley (Y-globe type only), Armstrong, Nibco (Globe style), Tyco-Grinnell, Oventrop, or Victaulic/Tour & Anderson or Gruvlok(Y-globe type only), #Series 786 (soldered), #Series 787 (threaded), #Series 788 (flanged) or #Series 789 (grooved), Nexus Valve, or equal.

2.6 TERMINAL UNIT ASSEMBLIES – COIL KITS

A. General: As an alternative to built-up valve and connection assemblies for terminal units, a complete kit consisting of valves, strainer, balancing, and flexible hose connection may be provided. Refer to Section 230548 Vibration Isolation for Piping, Ductwork and Equipment specification for additional requirements for flexible hose. Manufacturers: Victaulic #Koil Kit Series 799 or 79V, Pro Hydronic Specialties, Hays Fluid Controls, IMI #Versaflow, or equal.

2.7 BRANCH CIRCUIT DIFFERENTIAL PRESSURE CONTROL VALVES

A. Self-powered control valves designed to maintain constant differential pressure for branch circuits and consisting of a differential control, single pressure temperature port, and dead end service shutoff. Shall be capable of stabilizing pressure ranges of 1.5 to 8.7 psi in 3/4" to 1" valves, 2.9 to 11.6 psi in 1-1/4" -2" valves, or 51 psi for 2-1/2" through 4" valves.

B. Bonnet shall be manufactured of copper alloy, O-rings, seat seal, and membrane to be EPDM.

C. Manufacturers: Tour & Anderson #793/794 used in conjunction with Victaulic/Tour&Anderson balancing valves, or equal.

2.8 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES (COIL CONTROL VALVES)

A. See BAS specification
2.9 HYDRONIC SYSTEM PRESSURE REDUCING VALVES

A. Single seated, direct operated type; high capacity, having bronze body with strainer, by-pass feature, pressure gauge tappings and complying with requirements of ASSE Standard 1003. Select proper size for maximum flow rate and fall-off at inlet and outlet pressure indicated.
   1. 25-75 psig range. Manufacturers: Watts #LFU5B-Z3, Zurn #600XL or equal.
   2. For applications where reducing valve is used in hot water systems provide with asbestos-free insulating cover, with silicone treated fiberglass cover, 1" insulation, and Velcro fasteners. Suitable for temperatures up to 550°F. Manufacturers: Spence #Series E or equal.

2.10 HYDRONIC SYSTEM PRESSURE RELIEF VALVES

A. Pressure Relief Valves: Constructed in accordance with ASME, 125-pound setting, and so stamped. Size as required. Manufacturers: Watts #740 Series or equal.

B. Temperature and Pressure Relief Valve: Constructed in accordance with ASME, 125-pound setting (or pressure setting as indicated on construction documents), and so stamped. Size as required. Manufacturers: Watts #100XL, 40XL, 140, N240, or 340 Series, or equal.

2.11 THERMOMETERS AND GAUGES

A. General:
   1. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.
   2. No mercury shall be used in thermometers due to hazardous material classification.

B. Thermometers:
   1. Bi-Metal Type: Provide bi-metal glass thermometers of materials, capacities, and ranges indicated, designed and constructed in service indicated. Accuracy shall be 1% +/- full scale with adjustable recalibration.
      a. Case: Type 300 series stainless steel, hermetically sealed, glass window, 3” diameter dial, with adjustable angle.
      b. Adjustable Joint: Die cast aluminum, finished to match case, 180° adjustment in vertical plane, 360° adjustment in horizontal plane, with locking device.
      c. Scale: Satin faced, non-reflective aluminum, permanently etched markings.
      d. Stem: Stainless steel, adjustable angle socket, length to suit installation.
   2. Glass Thermometer: Provide adjustable angle 9” thermometer of materials, capacities and ranges as appropriate to medium being measured and designed and constructed for service indicated. Accuracy to be 1% +/- of full scale.
      a. Case: Aluminum or Valox.
      c. Scale: Aluminum painted white with black markings.
      d. Connection: 1/2" NPT with thermowell, 1-1/4" UNF swivel nut without thermowell.
   3. Photovoltaic Cell Powered LCD Thermometer
      b. Accuracy: 1% of full scale.
      c. Display: 16 LUX rating LCD display. Switchable Fahrenheit and Celsius.
      d. Connection: 3/4" NPT with thermowell 1-1/4" UNF swivel nut without thermowell.
   4. Range: Conform to the following:
C. Sensor Test Wells:
   1. Provide control device test wells as indicated and as required by the BAS. Constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 3" extension for insulated piping. Provide shutoff valves to isolate sensor for maintenance and removal.

D. Thermometer Test Wells:
   1. Provide 1/4" thermometer test wells as indicated and as required by the BAS. Constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 3" extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

E. Temperature/Pressure Gauge Connector Test Plugs (Pete’s Plugs):
   1. Provide temperature gauge connector plugs pressure rated for 500 psi and 200° F (93° C). Construct of brass or stainless steel, equip with 1/2" NPT fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8” O.D. probe assembly from dial type insertion thermometer or pressure gauge. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.

F. Pressure Gauges:
   1. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.
   2. Type: General use, 1% accuracy ANSI B40.1 grade A, phosphor bronze bourbon type, bottom connection.
   3. Case: Drawn steel or brass, glass lens, 4-1/2" diameter.
   4. Connector: Brass with 1/4" male NPT.
   5. Scale: White coated aluminum, with permanently etched markings.
   6. Pressure differential range shall be 100 psig minimum for the appropriate application with maximum 1 psig divisions.

G. Pressure Gauge Cocks:
   1. General: Provide pressure gauge cocks/valves between pressure gauges and gauge tees on piping systems. Two-piece bronze body ball valve with threaded ends. Manufacturers: Milwaukee #BA-100 or equal.
   2. Snubber: 1/4" brass or stainless steel bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating. Manufacturers: Wika #910.12, Ashcroft #1112, or equal.

2.12 PIPING SPECIALTIES

A. General:
   1. Provide factory fabricated piping specialties recommended by manufacturer for use in service indicated. Provide piping specialties of types and pressure ratings indicated for each service, or provide proper selection to comply with installation requirements. Provide sizes as indicated, and connections, which properly mate with pipe, tube, and equipment connections. Where more than one type is indicated, selection is installer’s option.

B. Strainers - Low Pressure Y-Type Pipeline Style:
   1. Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 150% (minimum) of the working pressure of piping system.
2. Threaded Ends, 2” and Smaller: Cast-iron body, conforming to ASTM A126, screwed screen retainer with centered blowdown fitted with hose bibb. Manufacturers: Spirax Sarco, Keckley, Wheatley, Mueller, or equal.

3. Flanged Ends, 2-1/2” and Larger: Cast-iron body, conforming to ASTM A126, bolted screen retainer with off-center blowdown fitted with 3/4” drain valve. Manufacturers: Spirax Sarco, Metraflex #LPD, Keckley, Wheatley, Mueller, or equal.

4. Grooved Ends, 2-1/2” and Larger: Ductile iron body, conforming to ASTM A395 and ASTM A536, bolted screen strainer with off center blowdown fitted with 3/4” drain valve. Manufacturers: Victaulic #Style 730/731/732, Tyco-Grinnell #Fig. S853 and S55, Gruvlok #FIG 7260/758G, or equal.

5. Strainer screen or basket, Type 304 stainless steel or better.
   a. Start-up screen for first month of operation shall be a 40 mesh with 0.016” openings and 41% open area. For applications with piping connected to existing piping systems the start-up screen shall be 60 mesh with 0.010” openings and 38% open area.
   b. Start-up screen shall be removed and replaced with normal operation screen after one month of pump operation, or as directed by the water treatment company, and prior to final water balance.
   c. Normal operation screens or baskets, shall be installed prior to final water balance.
      1) Strainer sizes up to 2” shall be provided with 20 mesh screens, with 0.035” openings and 49% open area (minimum).
      2) Strainer sizes 2-1/2” and larger shall be provided with perforated baskets with 3/64” diameter perforations with 36% open area (minimum).

C. Unions:
   1. Unions shall be of type specified in following schedule:
      a. Black Steel, 2” and smaller: 250 lb. screwed malleable iron, ground joint, brass to iron seat.
      b. Black Steel, 2-1/2” and larger: 150 lb. cast iron screwed flanged, flat faced, full faced gasket.
      c. Stainless Steel, 2” and smaller: 300 psi maximum operating pressure, threaded union, with Vic Press 304™ ends.
      d. Soldered Copper or Brass Pipe, 2” and smaller: 150 lb. cast bronze or copper, ground joint, non-ferrous seat with soldered ends.
      e. Screwed Copper or Brass Pipe, 2” and smaller: 150 lb. cast brass, ground joint, brass to brass seat, with threaded ends.
      f. Flanged Copper or Brass Pipe, 2-1/2” and larger: two (2) 150 lb. cast bronze flanges.
      g. Where grooved joint piping systems are utilized, unions are not required. Grooved joint couplings shall serve as unions.
      h. Manufacturers: EPCO, Mueller, Stanley G. Flagg, Victaulic, Tyco-Grinnell, Watts, or equal.
   2. Dielectric Unions:
      a. Provide standard products recommended by manufacturer for use in service indicated to effectively isolate ferrous (galvanized steel, black steel, zine coated steel) from non-ferrous piping to prevent galvanic action and related corrosion.
      b. Manufacturers: Watts #LF3000 Series, Zurn #DUX Series, or equal.

D. Dielectric Waterways:
   1. To effectively isolate ferrous from non-ferrous piping (electrical conductance), prevent galvanic action, and stop corrosion.
   2. Steel to copper, with thermoplastic dielectric lining.
   3. 250 psig rated pressure at 210°F.
   4. Connection: screwed, grooved, sweat, or flanged to match pipe.
   5. Manufacturers: Victaulic #Style 647, Gruvlok #FIG 7088/7089/7090 or equal.
E. Dielectric Flanges: Provide dielectric flanges and dielectric bolt sleeves for flanged transitions between dissimilar metal piping. Manufacturers: Watts Series 3100 or approved equal.

F. Flanges:
1. Provide flanges at flanged connections to equipment, tanks and valves. Faces of flanges being connected shall be alike in all cases. Connection of raised-face flange to flat-faced flange not permitted.
2. Use ASTM A307, Grade B, bolts and nuts for cast iron flanges and ASTM A193 for steel flanges. Regular square head unfinished bolts with heavy semi-finished hex nuts ASTM A194. Cadmium plated where exposed to weather. Rating: 150 lb. or 300 lb. in high pressure portions.
3. Type of pipe and corresponding flanges as follows:
   a. Screwed Black Steel Pipelines: 125 lb. black cast iron screwed flange, flat faces.
   b. Stainless Steel Pipe, Class 150 stainless steel flange adapter with carbon steel back-up flange and Vic Press 304™ end.
   c. Welded Steel Pipe, 150 lb. black forged steel welding flanges, 1/16” raised face ASTM A181 Grade I. Use flat face when connected to flat faced companion flange.
   d. Grooved Steel Pipe, Class 150, ASTM A395 and A536 ductile iron flange adapter, with pressure responsive synthetic rubber gasket. Manufacturers: Victaulic #Style 741, Tyco-Grinnell #Fig. 71, Gruvlok #FIG 7401, or equal.

G. Flange Gaskets:
1. Type: full faced or flat ring to suit flange facings.
2. Shall conform to ASTM F-104
3. Minimum thickness: 1/16”
4. Manufacturers: Garlock style 3200 or equal.

H. Pipe Sleeves:
1. Provide fire proof sleeve assemblies utilizing UL rated sealant systems at all fire rated penetrations. For non-rated sleeve penetrations pack the annular space between the pipe and sleeve with fiberglass and/or mastic.
2. Sleeves shall provide a minimum 1/2-inch annular clearance around pipe.
3. Sheet metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gauges: 3” and smaller, 20-gauge; 4” to 6”, 16-gauge; over 6”, 14-gauge.
4. Steel pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.
5. Iron pipe: Fabricate from cast iron or ductile-iron pipe; remove burrs.
6. Plastic and copper pipe: Fabricate from Schedule 80 PVC plastic pipe; remove burrs.
7. Sleeves through interior concrete walls and floors. Floor sleeves to extend a minimum of 1” above finished floor. Telescopic, submerged, or adjustable sleeves. Manufacturers: Adjust-to-Crete, AMI, Shamrock, or equal.
8. Through exterior walls and floor on grade: 150-pound class cast-iron pipe sleeve. Where waterproof membranes are used, provide membrane clamps. For insulated piping, sleeve diameter shall not be less than diameter of insulated pipe.
9. Cast-in-place watertight device for protecting penetrating objects from expansion and contraction of concrete. Factory-assembled for use in cast-in-place concrete floors and walls and consisting of two outer sleeves and a one-piece radial extended-flange waterstop gasket, with mid-body seal for embedment and sealing to concrete slab and continuous water seal extending to the penetrating pipe.
   a. Outer Sleeves: EPDM or NBR attached to the mid-body seal forming an area with which to attach the device to the structural reinforcing rod determining the position of sleeve in the wall.
b. Water Stop Mid-Body Seal: Flexible polymer seal with radial extended flange consisting of one to three concentric raised rings which lock into concrete, maintaining seal over time as concrete contracts from sleeve.

c. Manufacturers: Hubbard Enterprises/HOLDRITE, Hydro Preseal, or equal.

I. Sleeve Seals:
1. All sleeves shall be sealed to prevent intrusion of moisture, dust or insects.
2. Underground: For sleeves passing through exterior or foundation walls, provide mechanical link seal assembly.
3. Aboveground: For sleeves passing through walls or floors provide a non-toxic 3-hour rated fire resistant silicone foam sealant with a Flame Spread Rating of 20. Sealant to be tested and approved under UL 263, ASTM E119, and NFPA 251 Standards. All fire rated penetrations shall be sealed with approved UL System.
4. Local Approvals: All seals to be provided shall be in accordance with the regulations of all governing agencies of the city, county, and State Fire Marshal's Office.

J. Watertight Sleeve-Seal Systems:
1. Wood Decking Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in concrete floors formed with wood decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, fire, and hot gasses.
   a. Consists of an outer sleeve lined with an intumescent strip, and a radial extended flange attached to one end of the sleeve for fastening to concrete formwork.
   b. Include a waterstop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab.
   c. Retain subparagraph below if fire resistance rating is required.
   d. Provide a one-hour, two-hour, or three-hour fire-resistance rated assembly as required at penetration when tested according to ASTM E 814 or ANSI/UL 1479.
   e. Manufacturers: Hubbard Enterprises/HOLDRITE, Hydroflame Sleeve, or equal.
2. Metal Decking Description: Cast-in-place, factory-assembled, one-piece watertight firestop device for use in floors formed with steel decking to protect penetrating objects from expansion and contraction of concrete, thermal and seismic movement, and the passage of air, smoke, hot gasses and fire.
   a. Consists of an outer sleeve lined with an intumescent strip, and wide outside wings attached to one end of the sleeve for fastening to metal deck concrete formwork and span deck corrugations.
   b. Includes a cone attached to the base for extending the device through the metal deck and a waterstop gasket and mid-body seal consisting of one to three concentric raised rings for embedment and sealing to the concrete slab.
   c. Provide a one-hour, two-hour, or three-hour fire-resistance rated assembly as required at penetration when tested according to ASTM E 814 or ANSI/UL 1479.
   d. Manufacturers: Hubbard Enterprises/HOLDRITE, Hydroflame CMD Metal Deck Device, or equal.

K. Pipe Escutcheons:
1. Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime zinc base paint finish for unoccupied areas.
2. Pipe Escutcheons for Moist Areas: For waterproof floors and walls, and areas where water and condensation can be expected to accumulate, provide stainless steel, cast brass or sheet brass escutcheons, solid or split hinged.
3. Pipe Escutcheons for Dry Areas: Provide stainless steel escutcheons, solid or split hinged.

L. Drip Pans:
   1. Provide drip pans fabricated from 20-gauge galvanized sheet metal with watertight joints, and with edges turned up 2-1/2”. Reinforce top by structural angles. Provide hole, gasket, and flange at low point for watertight joint and 1” copper drain line connection.

2.13 EXPANSION COMPENSATORS AND FLEXIBLE PIPING CONNECTIONS

A. General: Pipe expansion, in general, is to be absorbed in bends, swing joints, expansion loops, and offsets. All piping mains, branches and runouts shall be installed to allow for free expansion and contraction without developing leaks or undue stressing of pipe. Stresses shall be within allowable limits of ANSI B31.1 for pressure piping. Vertical piping for chilled water, heating water, and condenser water shall be provided with system flexibility to allow expansion compensation at each floor level without inducing stresses on branch piping. Expansion products to conform to the standards of the Expansion Joint Manufacturer’s Association. Expansion joints shall not require packing. Installer shall select materials and pressure/temperature ratings to suit intended service. Select packless expansion joints to provide 150% absorption capacity of calculated maximum piping expansion between anchors. All connections shall have ends to match piping system application.

B. Expansion Compensators (Pipe Compression and Extension): Multiple stainless steel bellows, hose, braid, shroud and flange end fittings. Manufacturers: Keflex #311 series, Metraflex #GIL04F series, or equal.

C. Flexible Expansion Joint/Seismic Connector for Steel Pipe: Stainless steel hose and braid, 180° return, CSA approved, and end fittings. Manufacturers: Metraflex #Metraloop, Unisource #V-SF21 Style, Mason Industries #VEE Assembly, or equal.

D. Flexible Connection for Steel Pipe (piping and equipment located outside the building): Stainless steel hose and braid, with threaded, grooved or flanged ends. Provide steel supports to prevent sagging as required. Manufacturers: Metraflex #SST, Mason Mercer, or equal.

E. Three grooved joint flexible type, not rigid, couplings may be used in lieu of flexible connectors on steel pipe for vibration attenuation and stress relief. Grooved joint couplings shall be placed in close proximity to the vibration source. For services up to 250°F. Manufacturers: Victaulic #Style 177 or 77, Tyco Grinnell #Fig. 705 and 707 couplings, or Gruvlok #FIG 7401.

F. Flexible Connection for Copper Pipe: Bronze hose and braid, copper tube ends. Provide steel supports to prevent sagging is required. Manufacturers: Metraflex #BBS, Unisource #V-BF11 Style, Mason Industries or approved equal.

G. Flexible Rubber Connectors (Pump Connections): Concentric spool type expansion joint, single or double arch. Chlorobutyl tube and cover, meeting ASTM specification D2000 Grade 2AA610AB, L13. The body shall be reinforced with rectangular body rings and a minimum of six bias plies of polyester fabric. A hypolon coating shall be applied completely and uniformly to the cover. All expansion joints shall be rated 190 psi/26-inch vacuum at 250°F for sizes up to and including 12 inches.
   1. For chilled water, condenser water, and non-critical pump connections. Furnish with fluorelastomer tube and cover to ASTM D2000 Grade 1HK710. The body shall be reinforced with rectangular body rings and six bias plies of fiberglass/kevlar fabric rated 190#/26-inch vacuum at 250°F. Provide galvanized flat (not L shaped) back up rings.
and control rods to limit maximum axial extension. Manufacturers: Garlock #206 EZ-FLO or equal.

2. Three grooved joint flexible type couplings may be used in lieu of flexible connectors on steel pipe for vibration attenuation and stress relief. Grooved joint couplings shall be placed in close proximity to the vibration source. For services up to 250°F. Manufacturers: Victaulic #Style 177 or 77 or Gruvlok #FIG 7401.

H. Expansion Joints for Grooved Piping: For piping systems fabricated from grooved pipe and couplings, use one of the following methods for expansion compensation:

1. Combination Couplings and Nipples: Provide expansion joints constructed of grooved short pipe nipples and flexible couplings, designed by manufacturer to suit intended service. Provide removable ties to hold joint compressed or expanded during piping fabrication, depending on application. Total joint end movement is dependent on the number of couplings/nipples in the joint. Select couplings and gasket materials to match balance of piping system. Manufacturers: Victaulic #Series 155 or Gruvlok #FIG 7240.

2. Slip-Type Expansion Joints: Provide slip-type expansion joints constructed of carbon steel pipe and couplings, designed by manufacturer to suit intended service. Joint shall be gasketed expansion joint, with grooved ends. Slide section coated with PTFE modified PPS (Polyphenylene Sulfide) coating. Joint suitable for axial end movement up to 3”. Select couplings and gasket material to match balance of piping system. Manufacturer: Victaulic #Style 150 or equal.

3. Three flexible couplings: Use three flexible couplings for the first three connections in close proximity to a pump or chiller to eliminate flexible rubber connectors. Manufacturers: Victaulic #177, 75 or 77, Tyco-Grinnell #Fig. 705 and 707, or Gruvlok #FIG 7401.

I. Pipe Alignment Guides: Provide pipe alignment guides on both sides of expansion joints, and elsewhere as indicated on drawings. Guide shall be of carbon steel construction with split guiding cylinder and integral anchor base and internal four finger two-piece spider. Cylinder wall thickness shall be equal to schedule 40 wall thickness of pipe being guided. Spider shall be capable of clamping directly to pipe and moving only in an axial direction while inside cylinder. Anchoring directly to building substrate. Manufacturers: Metraflex #Style IV or equal.

J. Expansion Loops: Provide field fabricated pipe expansion loops as an alternate to mechanical expansion joints. Expansion loops in IPS steel and roll grooved copper tubing systems shall be accommodated with loops or bends consisting of eight (8) mechanical groove-type couplings, four (4) 90-degree elbows, and three (3) grooved end pipe spools provided in water systems up to 250°F in accordance with recommendations for expansion compensation.
C. Coordinate mounting and attachment of piping and tanks with Structural Engineering design.

D. Coordinate the work between the various Mechanical Sections and with the work specified under other Divisions of the work or contracts toward rapid completion of the entire project. If any cooperative work must be altered due to lack of proper supervision or failure to make proper provisions in time, then the work hereunder shall include all expenses of such changes as are necessary in the work under other contracts, and such changes shall be directly supervised by and made to the satisfaction of the Owner’s Representative.

E. The cooperative work not included in the Mechanical Division related to the general construction work is as follows:
   1. All formed concrete work
   2. Framed openings in masonry and other Architectural and Structural elements
   3. Wood grounds and nailing strips in masonry and concrete

F. Inspect all material, equipment, and apparatus upon delivery and do not install any that may be subject to rejection as a result of damage or other defects. Provide tarps and waterproof material cover to protect equipment and piping delivered to and stored at the site.

3.2 MANUFACTURER’S DIRECTIONS

A. Follow manufacturer’s directions and recommendations in all cases where the manufacturers of articles used on this Contract furnish directions covering points not shown on the Drawings or covered in these Specifications. Provide additional valves, strainers, unions, etc. as required by manufacturer installation instructions.

3.3 WORKING PRESSURES

A. All fittings, valves, pipe, specialties equipment shall be rated for the working pressure subjected in the installed locations.

B. Drawings indicate working pressure in each system. The rating of the equipment and material shall not be less than that of the system pressures.

3.4 PIPE SIZES TO EQUIPMENT

A. General: Pipe sizes indicated on drawings shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of equipment.

B. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valve.

3.5 PIPING INSTALLATION

A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints or couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16-inch misalignment tolerance. Comply with ASME B31 Code for Pressure Piping.

B. Locate piping runs, except as otherwise indicated, vertically and horizontally (pitched to drain) and avoid diagonal runs wherever possible. Orient horizontal runs parallel with walls and
column lines. Locate runs as shown or described by diagrams, details, and notations or, if not otherwise indicated, run piping in shortest route which does not obstruct space or block access for servicing building and its equipment. Hold piping close to walls, overhead construction, and other structural and permanent-enclosure elements of building. Limit clearance to 1/2 inch where furring is shown for enclosure or concealment of piping, but allow for insulation thickness, if any. Where possible, locate insulated piping for 1-inch clearance outside insulation. Whenever possible in finished and occupied spaces, conceal piping from view, by locating in column enclosures, in hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as indicated.

C. Install expansion joints, expansion loops, expansion bends, and similar units to accommodate project seismic movement across building expansion joints and in vertical risers to accommodate drift between vertical buildings levels.

D. 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.

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

F. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, and 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.

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

H. 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.

I. Check Valves: All check valves should be installed in a location that has smooth and laminar flow conditions. Use the following general rules for check valve installations:
   1. Downstream of a reciprocating pump or other turbulence inducing device (elbow, tee, etc.)
      a. Swing Type: Locate valve a minimum of 10-12 diameters downstream of the device.
      b. Silent Type: Locate valve a minimum of 4-5 diameters downstream of the device.
   2. Pipe fittings, elbows, reductions, etc. downstream of the valve:
      a. Swing Type: Locate elbow a minimum of 5-7 diameters downstream of the valve.
      b. Silent Type: Locate elbow a minimum of 2-3 diameters downstream of the valve.

J. Strainers
   1. Install strainers in piping and locate upstream of control valves, coils, and heat exchangers where shown on drawings and as required by equipment and controls manufacturers.
   2. Strainer screen or basket shall be Type 304 or 316 stainless steel.
      a. Start-up screen for first month of operation shall be a 40 mesh with 0.016” openings and 41% open area. For applications with piping connected to existing piping systems the start-up screen shall be 60 mesh with 0.010” openings and 38% open area.
      b. Start-up screen shall be removed and replaced with normal operation screen after one month of pump operation, or as directed by the water treatment company, and prior to final water balance.
c. Normal operation filter screens or baskets shall be installed prior to final water balance.
   1) Strainer sizes up to 2” shall be provided with 20 mesh screens, with 0.035” openings and 49% open area (minimum).
   2) Strainer sizes 2-1/2” and larger shall be provided with perforated baskets with 3/64” diameter perforations with 36% open area (minimum).

K. Coordinate all condensate piping from cooling coils with Division 22 work.

L. Elevator Machine Rooms, Switchgear, Generator, Telecommunications, Telephone Rooms, and Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures unless unavoidable. Install drip pan under piping that must be run through electrical spaces.

M. Cleaning: Clean exterior surfaces of installed piping systems of superfluous materials and prepare for application of specified coatings (if any).

3.6 SLOPING, AIR VENTING, AND DRAINING

A. Provide hose bibb valve, with threaded brass cap, at all low points in piping for maintenance drainage. Provide drains on each side of air handling coils and heat transfer devices. Provide drains at each low point in the piping on each floor level.

B. Connect all branch piping to the bottom or side of their respective hydronic mains. Where connections must be made to the top of the main piping, make provision for venting of air.

C. Provide drain discharge pipe from each temperature relief valve and/or pressure relief valve as required by mechanical code. Discharge pipes shall and discharge independently by gravity through an air gap into the drainage system or outside of the building with the end of the pipe not exceeding 2 feet (610 mm) and not less than 6 inches (152 mm) above the ground and pointing downwards, or indirectly terminated above an approved location such as a floor sink or floor drain.

D. Provide manual or automatic vents at all high points in water piping, at high points in the piping and adjacent to each coil, and where shown on the drawings.
   1. Manual air vents shall be located at the high points in all closed and open hydronic piping systems for manual air venting, including high points at coil connections, and where shown on the drawings. Provide at high points in piping system on each floor.
   2. Automatic air vents shall be provided in all closed hydronic piping systems and located on the top of air separators, boilers, chillers, pump skid high points, heat exchangers and other locations shown on drawing and as required for complete air venting of piping system. An automatic air vent, a minimum of one, shall also be installed at the highest point in each piping system where air is likely to migrate. Additional automatic air vents shall be provided as necessary if piping is installed with air pockets. Air vents shall be tightly sealed against loss of system water and prevent entrance of air in negative pressure situations. Route drain pipe to nearest floor drain or floor sink or other approved drainage location.

3.7 PIPING SYSTEM JOINTS

A. All piping shall be cut squarely, free of rough edges and reamed to full bore. Piping shall be mechanically cleaned prior to make-up of joints and fully inserted into fittings.

B. Provide joints of type indicated in each piping system.
C. Piping shall be capped during construction to prevent entry of foreign material.

D. Thread pipe in accordance with ANSI B2.1. Cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Remove excess cutting oil from piping prior to assembly. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

E. Soldered copper tube and fitting joints with lead free nickel/silver bearing solder meeting ASTM B-32, in accordance with IAPMO IS 3-93, ASTM B-828 and Copper Development Association recommended procedures. Joints shall be cleaned by other than chemical means prior to assembly. "Shock" cooling is prohibited. Fluxes shall be applied liberally to the outside of the pipe and the solder cup of the fitting. Fluxes shall be water soluble for copper and brass potable water applications and shall meet CDA standard test method 1.0 and ASTM B813-91. Solder shall be applied until a full fillet is present around the joint. Solder and flux shall not be applied in such excessive quantities as to run down interior of pipe. Lead solder or corrosive flux shall not be present at the jobsite. Soldered joints shall only be installed where complete access is available on all sides of the pipe to assure that visual inspection can occur for 360° circumference. Blind soldering is not allowed, in such cases the use of mechanical type fittings shall be utilized. This would apply to situations such as pipes attach tight to floor or ceiling/roof requiring mechanical type joints.
   1. Manufacturers:
      a. Solder: JW Harris "Bridgit" or Englehard "Silvakrite 100".
      b. Flux: Laco "Flux-Rite 90", MW Dunton "Nokorode CDA Flux", Hercules "Fluid Action Solder Flux".

F. Mechanically Formed Extruded Tee Fittings: Form tee in copper tube according to ASTM F2014. Forming procedures shall be in accordance with the tool manufacturer’s recommendations. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar. Formed tee fitting shall not be greater than 50% of the diameter of the main run tube/pipe. Soldered joints are not allowed.
   1. Mechanically formed extruded outlets shall be perpendicular to the axis of the run tube (main pipe). Holes shall be formed by drilling a pilot hole and drawing out the tube surface to form a collar having a height of not less than three times the thickness of the branch wall.
   2. Branch tubes shall not restrict the flow in the run tube. A dimple (depth stop) shall be formed in the branch tube to ensure that penetration into the collar is of the correct depth. For inspection purposes, a second dimple shall be placed 0.25 inch above the first dimple. Dimples shall be aligned with the tube run.
   3. Manufacturer: T-Drill or equal.

G. Braze copper tube and fitting socket or mechanically formed tee fittings with BCUP series filler metal without flux. Listed brazing flux shall be used for joining of copper tube to brass or bronze fittings and shall meet AWS FB3A or FB3C. "Shock" cooling is prohibited. A continuous fillet shall be visible around the completed joint. After cooling, flux residue shall be thoroughly removed with warm water and a brush prior to testing. Do not use BCUP filler on copper alloys containing over 10% nickel.
   1. Brazing fittings may use a mechanically limited depth that is not less than the minimum cup depth (overlap) specified by ANSI/ASME B16.50 for Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings. Manufacturer of mechanical dimpler: Brazing Dimpler Corp or equal.
H. Depth of solder joint and braze joint fitting:

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<th>Pipe Size (inches)</th>
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<th>ASME B16.50 Brazed Joint Socket Depth (inches)</th>
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I. Weld pipe joints in accordance with recognized industry practice and as follows:
1. Weld pipe joints only when ambient temperature is above 0°F.
2. Bevel pipe ends at a 37.5° angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.
3. Use pipe clamps or tack-weld joints with 1” long welds, 4 welds for pipe sizes to 10”, 8 welds for pipe sizes 12” to 20”.
4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and at edges of each weld. Weld by procedures which will ensure elimination of unsound or un-fused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.
5. Do not weld out piping system imperfections by tack-welding procedures. Re-fabricate to comply with requirements.
6. With engineering pre-approval stub-in saddle taps may be acceptable for aboveground branch connections, in non-critical areas, where the branch size is less than 50% of the main size and where branch sizes are 3”, or smaller, in diameter. Pipe main must be larger than 8” diameter in a renovation project for consideration.

J. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

K. Dielectric Fittings:
1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing such as copper to zinc plated equipment fittings or copper to galvanized steel or black steel equipment:
   a. Dielectric Fittings for NPS 2” (DN 50) and Smaller: Use dielectric couplings, nipples, unions.
   b. Dielectric Fittings for NPS 2-1/2” to NPS 4” (DN 65 to DN 100): Use dielectric flange kits or threaded nipples.
   c. Dielectric Fittings for NPS 5” (DN 125) and Larger: Use dielectric flange kits.
2. Dielectric couplings are not required in the following locations:
   a. Unions in a copper piping system with connections to brass/bronze valves and devices.
b. Unions in a copper piping system with connections to stainless steel valves and devices.

L. Adhesive Bonded Joints: All joints installed or constructed in the field shall be assembled by employees of the contractor who have been trained and certified to the bonding procedure specification provided by the pipe manufacturer. This specification shall meet or exceed the requirements of ASME B31.3, Section A328.2.1. The pipe manufacturer or their authorized representative shall train the contractor’s employees in the proper joining and assembly procedures required for the project including hand-on participation by the contractor’s employees in accordance with the manufacturer’s specification.

3.8 VALVES

A. General: Except as otherwise indicated, comply with the following requirements.
   1. Install valves where required for proper operation of piping and equipment, including valves in branch lines where necessary to isolate sections of piping, strainers and other equipment. Locate valves so as to be accessible and so that separate support can be provided as necessary.
   2. Install valves, except butterfly valves, with stems pointed up, in vertical position where possible, but in no case with stems pointed downward from horizontal plane without prior written approval. Install valve drains with hose-end adapter for each valve that must be installed with stem below horizontal plane.
   3. Install butterfly valves with stems mounted horizontally.
   4. All valves mounted higher than 10 feet above floor in mechanical rooms and where indicated shall be installed with stem horizontal and equipped with chain wheels and chains extending to 5 feet above floor.

B. Insulation: Where insulation is indicated, install extended-stem valves, arranged in proper manner to receive insulation.

C. Selection of Valve Ends (Pipe Connections): Except as otherwise indicated, select and install valves with the following ends of types of pipe/tube connections:
   1. Copper Pipe, 2-1/2” and Smaller:
      a. Soldered-joint valves.
      b. Grooved-joint valves.
   2. Copper Pipe, 2-1/2” and Larger: Grooved-joint valves.
   4. Steel Pipe, 2” and Smaller: Threaded joint valves.
   5. Steel Pipe, sizes 2-1/2” and larger: One of the following, at installer’s option:
      a. Flanged valves.
      b. Lug valves.
      c. Grooved-end valves.

D. Non-Metallic Disc: Limit selection and installation of valves with non-metallic discs to locations indicated and where foreign material in piping system can be expected to prevent tight shutoff of metal seated valves.

E. Renewable Seats: Select and install valves with renewable seats, except where otherwise indicated.

F. Fluid Control: Except as otherwise indicated, install gate, globe, ball, plug, circuit setter, glove, and butterfly valves to comply with ASME B31.9.
G. Check Valves: Install in vertical or horizontal a minimum of three (3) pipe diameters downstream of pump outlet.

H. Wafer Style Silent Check Valve: Install between two (2) flanges and use full size bolts to assure center alignment.

I. Ball Valve: Ball valve used on gas systems shall be UL listed, CSA approved for pressure of system, no exception

J. Valve Adjustment: After piping systems have been tested and put into service, but before final testing, adjusting, and balancing, inspect each valve for possible leaks. Adjust or replace packing to stop leaks, replace valve if leak persists.

K. Valve Identification: Tag each valve in accordance with "Mechanical Identification" section.

L. Cleaning: Clean factory-finished surfaces. Repair marred or scratched surfaces with manufacturer's touch-up paint.

M. Install so handles are readily available. Locate valves and valve handles for appropriate maintenance access.

N. Gasket and O Ring Material: Valve manufacturer is responsible for submittals. Provide gasket and O ring material best suited for the both piping systems.

3.9 TEMPERATURE GAUGES AND THERMOMETERS

A. General: Install temperature gauges/thermometers in vertical upright position and tilted so as to be easily read by observer standing on floor without supplemental illumination.

B. Install in the following locations and elsewhere as indicated:
   1. At inlet and outlet of chillers.
   2. At inlet and outlet of fluid coolers.
   3. At inlet and outlet of heat exchangers.
   4. At inlet and outlets of boilers.

3.10 PRESSURE GAUGES

A. General: Install pressure gauges in vertical upright position and tilted so as to be easily read by observer standing on floor without supplemental illumination. All gauges to be installed with snubbers to absorb system shock.

B. Install in the following locations and elsewhere as indicated:
   1. At inlet and outlet of pumps.
   2. At inlet and outlet of chillers.
   3. At inlet and outlet of heat exchangers.
   4. At inlet and outlet of boilers.

3.11 IDENTIFICATION MARKERS (SEE SECTION 230500)

3.12 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1” minimum annular clear space between piping/insulated piping and concrete slabs and walls.
   1. Retain subparagraph below when cast-in-place watertight sleeve seals are required.
   2. When cast-in-place watertight sleeve seals are required, select sleeve size to match the size and type of pipe to be installed.
   3. Retain subparagraph below if applicable.
   4. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2” above finished floor level.
   2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4” (6.4 mm) annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
   4. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."
      Exception: When fire-resistance-rated cast-in-place watertight sleeve seals are required for floor penetrations, additional firestopping is not necessary.

3.13 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

C. Aboveground, Cast-in-Place Watertight Sleeves. Select sleeve size based on pipe size, material to be inserted and thickness of wall.
   1. Install cast-in-place watertight sleeves for pipes NPS 6 (DN 150) and smaller in diameter.
   2. Position cast-in-place watertight sleeve in wall space securing sleeve to reinforcing steel using tie wire.

D. Fire-Resistance Rated, Cast-in-Place Sleeve Installation: Select sleeve size based on size and type of pipe and thickness of the floor. Position and secure sleeve to concrete form using nails or staples.
3.14 EXPANSION COMPENSATION

A. Expansion Loops/Connectors at Expansion Joints:
   1. Provide flexible hose expansion loop(s) or connectors as indicated on the contract drawings or as required to accommodate any thermal expansion, contraction, building settlement, or seismic movement of the piping system.
   2. Flexible hose expansion loops shall be manufactured complete with two parallel sections of corrugated metal hose, compatible braid, 180 deg return bend, with inlet and outlet connections. Field fabricated loops shall not be acceptable.
   3. Flexible loops shall be capable of movement in the ±X, ±Y, and ±Z planes to meet or exceed the limits identified in the structural design.
   4. Flexible hose expansion loops and connectors shall impart no thrust loads to system support, anchors or building structure.
   5. Provide pipe anchors and pipe alignment guides as indicated, and elsewhere as determined by installer to properly anchor piping in relationship to expansion loops.
   6. Where plans do not indicate spacing of guides or other pertinent information, install per manufacturer's recommendations.

B. Expansion Compensation for Risers and Terminals:
   1. Install connection between horizontal piping mains and vertical piping risers with at least five pipe fittings including tee in main. Install connections between piping risers and terminal units with at least four pipe fittings including tee in riser.

C. Thermal Expansion Compensation:
   1. Provide piping U-Bend, Z-Bend, L-Bend or flexible devices to accommodate thermal expansion and contraction in piping system where shown on drawings and as required to impart minimal stress in piping and building structure.

3.15 PIPE INSPECTIONS

A. It is the intent of the Contract Documents that systems be inspected at completion of each phase while under tests required for administrative authorities, and prior to concealment, i.e. "Rough-in" "Top-out" and final.

B. Inspection - Belowground: All piping installed underground shall be inspected prior to burial by the Owner's Representative. Provide photographs of underground piping in Operation and Maintenance Manuals including location and depth of pipes. Contractor must notify the Owner's Representative no less than 24 working hours prior to inspection time. Should the piping be buried without approval the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.

C. Inspection - Aboveground: All piping installed aboveground shall be inspected upon completion and prior to finish of walls and ceilings by the Owner's Representative. Contractor must notify the Owner's Representative no less than 24 working hours prior to inspection time. Should the piping be hidden within the structure prior to inspection approval the contractor may be requested to uncover the piping at no delay to the project and at no additional cost to the Owner.
3.16 FLUSHING AND CLEANING PIPING SYSTEMS

A. Clean systems with chemicals specified in Section 232500 HVAC Water Treatment. Follow the method provided below or a method recommended by the suppliers of the chemicals specified in Section 232500.

1. General Initial flushing:
   a. Remove loose dirt, mill scale, metal chips, weld beads, rust, and similar deleterious substances without damage to any system component.
   b. Provide temporary piping or hoses to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.
   c. Isolate or protect clean system components, including pumps and pressure vessels, and remove any components which may be damaged.
   d. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris-carrying velocity of 3 to 6 feet per second, if possible.
   e. Connect dead-end supply and return headers as necessary. Flush bottoms of risers.
   f. Install temporary strainers where necessary to protect down-stream equipment.
   g. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and contractor's booster pumps.
   h. Flush until clean as approved by the Owner's Representative.

2. Closed Circulating Water Systems:
   a. Fill system with local utility water; start circulation pump and vent high points manually until all air is released from the system.
   b. Flush the system with fresh water, drain a second time and refill. After final filling, the pH of the water must not exceed the pH of the fresh incoming water by more than 0.5 pH.
   c. Introduce the chemical cleaning solution into the system gradually by injecting into the suction side of the circulating pump, or by means of a pot (bypass) chemical feeder. If it is a chilled water system, do not turn on the compressor. If the system will be operating with a glycol/brine solution, use softened makeup water.
   d. While the water is being circulated, check to make sure that all passages are open and adequate flow velocity is present throughout the system.
   e. During circulation, open each drain connection for a short flow. Repeat at hourly intervals. Replace water drained during blowdown with chemical solution as required until air is eliminated from the system. The chemical cleanout procedure shall be continuous in this manner for two full 8-hour periods.

3. Open Condenser Water Systems:
   a. Fill system completely.
   b. Use an oxidizing disinfectant surfactant cleaner for cooling towers with non-metallic internal coatings. Use chemically neutral cleaner for cooling towers with galvanized coating. Use alkaline low foaming surfactant for stainless steel cooling tower systems.
   c. For packaged unit systems bypass the systems as necessary with temporary piping. For central chiller plants, protect heat exchangers with 150 mesh screens at heat exchanger inlets.
   d. Circulate water with high levels of cleaner for 4 to 8 hours.
   e. Test system pH at 60-minute intervals, pH should be above 10.0 while cleaning is taking place, unless water is flowing through a galvanized tower then pH remains between 7.0-8.0. Add more chemicals, to keep pH level. Have anti-foam on-site to prevent pump cavitiation.
   f. Flush entire system with fresh water to reduce pH within 0.5 pH of incoming water and test system pH, conductivity, alkalinity.
   g. Clean and flush circulators mud legs and strainers.
h. Isolate and drain cooling tower.

i. Clean/vacuum tower sump and distribution pan.

ej. Treat with water treatment chemicals at elevated dosage as necessary.

4. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body using the velocity of this throttling action. Flush for not less than one hour. Fill entire system with clean water and vent all air.

3.17 TESTING

A. Provide all tests specified hereinafter and as otherwise required. Provide all test equipment, including test pumps, gauges, instruments, and other equipment required. Test all rotational equipment for proper direction of rotation. Testing shall be witnessed by an independent third-party inspector. Upon completion of testing, certify to the Owner’s Representative, in writing, that the specified tests have been performed and that the installation complies with the specified requirements and provide a report of the test observations signed by third party inspector.

B. Piping: Remove from the system, during testing, all equipment which would be damaged by test pressure. Replace removed equipment when testing has been accomplished. The systems may be tested in sections as the work progresses; however, any previously tested portion shall become a part of any latter test of a composite system. Correct leaks by remaking joints with new material. During construction the installer may incrementally test portions of the piping system as allowed by the local mechanical code and/or ASME B31.1/B31.3/B31.9 as applicable.

C. Test time for the final pressure test and report will be accrued only while full test pressure is on the entire piping system. Pressure tests shall be witnessed by the Owner's Representative. Provide minimum 48-hour notice prior to start to each test. "Tolerance" shall be no perceptible pressure drop, except that due to temperature change in a 24-hour test period (minimum). Inspect and test all work prior to burying or concealing. Test pressure shall be 100 psig or 1.5 times the system operating pressure, whichever is greater. If approved by the local Authority Having Jurisdiction, the maximum test pressure may be limited to 50 psi greater than the operating pressure, but in no case less than 100 psig. Final test medium shall be water and pressure shall be applied and measured at the lowest floor level of the piping system. Confirm maximum pressure testing requirements with pipe manufacturer and do not exceed the maximum pressure rating of the piping.

D. Valves: Test all valve bonnets for tightness. Test operate all valves at least once from closed-to-open-to-closed position while valve is under test pressure. Test all automatic valves, including solenoid valves, and temperature and pressure relief valves, safety valves, and temperature and pressure relief valves not less than three (3) times.

E. Piping Specialties: Test all thermometers, pressure gauges, and water meters for accurate indication; automatic water feeders, and air vents for proper performance. Test all air vent points to ensure that all air has been vented.

3.18 WATER TREATMENT EQUIPMENT AND SYSTEMS

A. Install water treatment equipment and provide water treatment for systems as designated in Section 232500 HVAC Water Treatment and other Division 23 sections.
B. Close, fill system and provide chemical treatment as soon as possible after final flushing to minimize corrosion.

3.19 WATER ANALYSIS AND TREATMENT

A. Upon completion of systems installation, cleaning, and filling, engage a qualified water treatment firm, acceptable to the Owner's Representative. Treat systems with chemicals and procedures specified in Section 232500 HVAC Water Treatment. The water treatment firm shall perform a chemical analysis on each system listed hereinafter, and shall submit to the Owner's Representative a report, including the following:
   1. Analysis of each water system.
   2. Initial treatment of each system.
   3. Recommendations regarding subsequent, periodic, or continuous treatment on each system.

B. Contractor is to furnish and install initial treatment.

C. For all systems the contractor is to provide for periodic testing after startup and shall provide all recommended treatment for first year of building occupancy.

END OF SECTION
PART 1  GENERAL

1.1  APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this Section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic Materials and Methods, and other Sections in Division 23 specified herein.

1.2  SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 01, and shall include, but not necessarily be limited to, the following:
   1. Ductwork - Rigid, Flexible and Fabric.
   2. Diffusers, Grilles, and Registers.
   3. Ductwork Specialties.
   4. Flexible Connections.
   5. Sealants, Adhesives and Tapes.
   7. Backdraft and Relief Dampers.
   8. Control Dampers.
   9. Fan Powered Terminal Units.

1.3  RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic Materials and Methods.
B. Section 230593: Testing, Adjusting and Balancing.
C. Section 230713: Duct Insulation.
D. Section 230900: Building Automation System (BAS) Control.
E. Division 26: Electrical.

1.4  QUALITY ASSURANCE

A. Codes and Standards: Provide products conforming to the requirements of the following:
   5. ASHRAE Standard 130: Methods of Testing Air Terminal Units.
   9. American Society for Testing and Materials (ASTM): Manufacture and test in accordance with the ASTM Standards, including:


10. Underwriters Laboratory (UL): Manufacture and test in accordance with the UL Standards, including:
   a. 181: Standard for Factory-Made Air Ducts and Air Connectors.
   c. 181B: Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors.
   d. 268A: Standard for Smoke Detectors for Duct Application.
   e. 555: Standard for Fire Dampers.
   f. 555C: Standard for Ceiling Dampers.
   g. 555S: Standard for Smoke Dampers.
   h. 723: Standard for Test for Surface Burning Characteristics of Building Materials.

B. Provide and construct ductwork systems in conformance with the latest editions of the following documents:
   1. SMACNA HVAC Duct Construction Standards-Metal and Flexible.
   2. SMACNA HVAC Air Duct Leakage Test Manual.
   3. SMACNA HVAC Phenolic Duct Construction Standards.
   4. SMACNA - Accepted Industry Practice for Industrial Duct Construction" for duct pressures above +5" w.g. positive pressure or below -5" w.g. negative pressure. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the two standards.

C. Alternatives: The SMACNA standards and publications referenced in this Section of the specifications establish ductwork construction requirements.
   1. Alternatives to these standards and publications may be submitted. Approval will be based on demonstration that such alternatives are equivalent and satisfy the functional requirements described in the referenced standards.
   2. Such demonstration shall include evidence that the alternatives proposed were tested in accordance with SMACNA procedures and with test results certified by an independent testing laboratory.

D. All ductwork and equipment shall be seismically supported and braced to meet or exceed the minimum requirements of "SMACNA Seismic Restraint Manual-Guidelines for Mechanical Systems" and local building code requirements.

E. Flame/Smoke Rating: All materials, including sealants and adhesives, exposed within plenum shall be noncombustible or have a flame-spread index of 25 or less, and smoke developed index of 50 or less, as tested by ASTM E84 (NFPA 255) Method or UL 723. All materials installed within a plenum shall meet these requirements or have a safety data sheet available to indicate that materials are non-combustible. In addition, the products, when tested, shall not drip flame particles, and flame shall not be progressive. Provide Underwriters Laboratories, Inc., label or listing; or satisfactory certified test report from an approved testing laboratory to prove the fire hazard ratings for materials proposed for use do not exceed those
specified. Discrete plumbing, mechanical, and electrical products that are located in a plenum and have exposed combustible material shall be in accordance with UL 2043.

1.5 DEFINITIONS

A. Class 0: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a surface burning characteristic of zero. Typically constructed of semi-rigid corrugated aluminum. This does not include sheet metal ductwork constructed per SMACNA Standards.

B. Class 1: Factory-made air ducts and connectors, compliant with ANSI/UL 181, having a flame spread index of not over 25 and a smoke developed index of not more than 50. Typically constructed of flexible ductwork, rigid fiberglass ductwork and plastic ductwork. This does not include sheet metal ductwork constructed per SMACNA Standards.

C. Flexible Air Duct (Factory-Made): Class 0 or Class 1 air ducts tested in accordance with 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Flexible ducts shall not be installed to serve more than two stories and shall not penetrate a fire-resistance rated assembly or construction. Maximum lengths of flexible ductwork shall not exceed lengths identified in this section or as limited by the AHJ, whichever is shorter.

D. Flexible Duct Connector (Factory-Made): Class 0 or Class 1 connectors tested in accordance with 12 of 15 tests per ANSI/UL 181 and installed in conformance with the conditions of the listing and NFPA 90A/90B. Connectors include, but are not limited to, short flexible connections between air handlers and ductwork systems, uninsulated transition fittings, specialty shapes for diffuser connections, etc. Connectors shall not penetrate a wall, floor, or ceiling. Maximum lengths of flexible ductwork shall not exceed five foot (5') lengths or as limited by the AHJ, whichever is shorter.

1.6 SUBMITTALS

A. Prior to construction, submit for approval on all materials and equipment:
   1. Ductwork - Rigid, Flexible and Fabric.
   2. Ductwork Specialties.
   3. Flexible Connections.
   4. Sealants, Adhesives and Tapes.
   5. Duct Access Panels and Doors.
   7. Control Dampers.
   8. Diffusers, Grilles, and Registers.
   9. VAV Boxes.
   10. SMACNA "HVAC Duct Construction Standards - Metal and Flexible".

B. Shop Drawings: Provide shop drawings of sheet metal ductwork and plenums as follows:
   1. Draw to a scale not less than 1/8" to one foot, with sheet sizes equal to Contract Drawings.
   2. Show duct sizes, where possible use even duct sizes.
   3. Show fitting details.
   4. Show coordination with lighting fixtures, fire dampers, fire/smoke dampers, piping, diffusers, grilles, registers, fans, major electrical runs, cable trays and bus ducts.

C. Shop Drawings: Provide shop drawings for field erected mechanical equipment:
   1. Draw to a scale of 1/2” to one foot, with sheet sizes equal to Contract Drawings.
   2. Show plan, sections, elevations and details of all joints and enclosures.
3. Detail access doors and hardware.
4. Detail coil, damper, humidifier, filter and fan installations.
5. Show access space for electrical components that are part of the equipment provided and/or installed such as power and control panels on humidifiers. This shall be coordinated with Division 26 and NEC.

D. Certifications: Provide a duct schedule, certified by an officer of the sheet metal fabrication subcontractor, that the ductwork conforms to SMACNA standards, and for each sheet metal system furnished on the project include:
   1. System name.
   2. Duct material.
   3. Duct gauge.
   4. SMACNA rectangular reinforcement number.
   5. SMACNA intermediate reinforcement number.
   6. SMACNA transverse reinforcement number.
   7. Rod diameter and type.
   8. Sealant type.
  10. Duct system design pressure.

E. Construction IAQ Management Plan: Collaborate with the general contractor to submit and implement an IAQ Management Plan for the construction process meeting the requirements of the SMACNA IAQ Guidelines. This plan should address the protection of the ventilation system components during construction and cleanup of contaminated components after construction is complete. SMACNA IAQ Guideline recommends control measures in five areas. The IAQ Management Plan should address how compliance has been achieved in these required five areas as follows:
   1. HVAC Protection
      a. Shutdown of return side of existing HVAC system in areas affected by heavy construction.
      b. Provision of temporary filters if existing or new systems must remain operational during construction.
      c. Close the supply, return and exhaust dampers and seal duct openings in areas subject to construction dust.
   2. Source Control
      a. How will reduction of contaminants be reduced at the source?
      b. What steps will be taken to employ low emitting products and sealants.
      c. How will air handling equipment be cycled off when not needed?
   3. Pathway Interruption
      a. Describe how the construction space will be ventilated as required to dilute contaminants.
      b. Describe how occupied spaces adjacent to construction areas will be kept at positive pressure relative to spaces under construction.
   4. Housekeeping: Describe how the following housekeeping objectives will be implemented:
      a. Reduction of dust generated by work will be suppressed.
      b. Maintaining a frequent cleaning frequency for dust and particulates.
      c. Remove spills or excess applications of solvent-containing products as soon as possible.
      d. Remove accumulated water and keep work areas as dry as possible.
      e. Protect insulation materials from exposure to moisture.
   5. Scheduling: Describe how overlap of construction activity and ongoing building occupancy activities will be minimized.
F. Field Manual: Submit one copy of the SMACNA "HVAC Duct Construction Standards - Metal and Flexible". Maintain a second copy on the project site.

G. Any ductwork installed without prior approval by the specifier, shall be replaced at the expense of the contractor.

H. The contractor must comply with the enclosed specification in its entirety. If on inspections, the specifier finds changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor's expense.

I. At the discretion of the specifier, sheet metal gauges and reinforcing may be checked at various times to verify all duct construction is compliant.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site in containers with manufacturer’s stamp or label affixed.

B. Store and protect products against dirt, water, chemical, and mechanical damage. Do not install damaged components. Remove damaged products from project site.

1.8 WARRANTY

A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.1 DUCTWORK

A. Construct all ducts and plenum of gauges, and with joints, bracing, reinforcing, and other construction details in accordance with the latest construction standards previously listed. Metals shall be manufactured by United States Steel, Nucor or equal.

B. Duct dimensions indicated on drawings are net, inside, clear dimensions. For internally lined ducts, add lining thickness to determine metal duct dimensions.

C. Ducts shall be constructed of material gauges and reinforcement Class per SMACNA pressurization classifications to meet 150% of the pressure requirements for external static pressure scheduled on drawings for the fans serving each system. Where differences exist between SMACNA and the prevailing building code, the gauge or construction method of the submitted ductwork shall be the more stringent of the code or standard. Refer to Part III - Execution for matrix of pressure and leakage requirements.

D. Ductwork gauge shall not be thinner than 26-gauge for all work.

2.2 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 (Z180) for ductwork inside the building envelope in non-corrosive environments. G90 (Z275) for ductwork installed external to the building and may be installed inside the building as an alternate to G60.

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 the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized. 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.

G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 DUCTWORK FABRICATION

A. Rectangular Ducts
   1. Longitudinal Seams:
      a. Grooved seam flat/pipe lock (L-3), standing seam (L-4), single corner seam (L-5) or butt/corner weld for +/- 10 in. w.g. service. Snaplock and button-lock (L-1 and L-2) type joints are only allowed when ductwork is installed inside the conditioned space and when duct static pressures are less than 2” w.c. (500 Pa) or these type of joints must be reinforced with screws, soldering or welding when located in unconditioned areas or outside the insulated envelope.

   2. Lateral Joints:
      a. Slip drive joints, standard seams, flanges or welding as required by SMACNA HVAC Duct Construction Standards for system static pressure and sealed airtight. Flanged and gasketed joint fittings, such as Ductmate 25/35/45, Carlisle, MEZ Industries, or equal, are acceptable joint methods, but must be sealed as described previously. Transverse duct joints shall be constructed per Figure 1-4 for types T-8 through T-25. T-1 and T-5 slip joints are NOT allowed for transverse duct joints. T-5 slip joints may be used at connections to fire and smoke dampers as breakaway connections. Joint T-2, T-3, T-6 and T-7 reinforced slip joints are allowed below 2” static pressures.
      b. Exposed Ductwork: All sealant or gaskets applied internally within joint.
      c. Concealed Ductwork: All sealant or gaskets applied internally within joint.
      d. Welded where required for leakproof and airtight operation and per code.

B. Round Ducts
   1. Longitudinal Seams:
      a. Spiral seam (RL-1), butt weld (RL-4), or grooved seam flat PIPE lock (RL-5) for +/- 10 in. w.g. service.
2. Lateral Joints:
   a. Exposed Ductwork: Beaded sleeve joint (RT-1), crimp joint bead (RT-5), or flange type joint. All joints secured with sheet metal screws. All sealant applied internally within joint.
   b. Concealed Ductwork: Same as exposed ductwork, or sealant may be applied to the exterior side of joints.
   c. Welded where required for leakproof and airtight operation.

C. Elbows
   1. Construct long radius elbows with centerline not less than 1.5 times the duct width. Shorter radius elbows may be used where required to fit in restricted spaces, or as shown. For rectangular ductwork provide single thickness turning vanes on all short rectangular elbows less than 25" wide or provide double thickness turning vanes for short rectangular elbows 25" wide and greater. Number of vanes per SMACNA. Elbows with square throat and radius heel are NOT allowed.

D. Transitions
   1. Construct transitions to not exceed the slopes identified per SMACNA HVAC Duct Construction Standards-Metal and Flexible. Slopes shall generally be no greater than 15%, and no greater than 30% where shown on the drawings.

E. Branch Connections
   1. Provide 45° entry boots or radius taps for rectangular duct take-offs. Provide conical, bellmouth or 45° lo-loss boot taps for round duct take-offs. Straight 90° taps and spin-in taps are not allowed, except where round take-off duct size equals height of branch duct size. Provide volume dampers at each duct take-off for balancing. Provide insulation guards at transitions to lined ductwork.

F. Manufactured Joints
   1. 316 stainless steel adjustable clamps with gaskets for connecting welded laterals, branches, and Y fittings. Manufacturer: CECO Environmental #KB Duct or equal.

2.4 RECTANGULAR DUCTWORK

A. Construct rectangular ductwork to meet all functional criteria defined in of the SMACNA HVAC Duct Construction Standards-Metal and Flexible. All ductwork must comply with all local, code requirements. Ductwork shall be constructed of galvanized steel. Diagonally cross break all panels on ducts 30 inches wide and larger, or bead using automatic bead machine with beads at 12 inches on center or less. All connections shall utilize 45° boot take-offs. Bullhead tees and straight taps are not permitted.
   1. Listed manufactured ductwork system are allowed where they are installed per the manufacturer’s installation instructions and meet or exceed the requirements of the design requirements.

2.5 ROUND AND OVAL DUCTWORK

A. Round and oval ductwork shall be constructed to SMACNA round ductwork requirements of galvanized sheet steel. Comply with SMACNA HVAC Duct Construction Standards-Metal and Flexible, based on indicated static-pressure class unless otherwise indicated. Longitudinal seams shall be spiral lock seams or continuous welded. Flat oval may be utilized in space-restricted areas. All elbows shall be long radius type with centerline radius to duct diameter of 1.5, exceptions will only be allowed at restricted space locations.
B. Round or oval duct and fitting manufacturers:
   2. Lindab.
   4. Sheet Metal Connectors.
   5. Spiral Manufacturing.
   7. Spiral Fittings.
   8. Or equal.

C. Flat-Oval Ducts:
   1. 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:
   1. Fabricate according to SMACNA HVAC Duct Construction Standards-Metal and Flexible,
      for static-pressure class, applicable sealing requirements, materials involved, duct-
      support intervals, and other provisions. All transverse joints, including mechanical flange
      type fittings, to be externally sealed at all joints.
   2. Exception: internal manufactured single or dual EPDM rubber gasket fittings do not
      require external sealant.
   3. Transverse joints in ducts larger than 50" diameter require flanged joints.
   4. Lap or snap lock seams are not permitted for round ductwork of any size.

E. Longitudinal Seams:
   1. Select seam types and fabricate according to SMACNA 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 HVAC Duct Construction Standards-Metal
      and Flexible. All longitudinal joints shall be sealed airtight with sealant or continuous
      welding.
   2. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal
      seams.
   3. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-
      welded longitudinal seams.

F. Tees and Laterals:
   1. Select types and fabricate compliant with SMACNA HVAC Duct Construction Standards-
      Metal and Flexible, Figure 3-5, "45 Degree Tees and Laterals", and Figure 3-6, "Conical
      Tees" and "45 Degree Boot Tees" for static-pressure class, applicable sealing
      requirements, materials involved, duct-support intervals, and other provisions.
   2. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted.

G. Elbows:
   1. Any deviation from a straight run shall be made using a gored or welded elbows or
      stamped elbows. Normal 90-degree elbows may include 5-gore fittings and the radius of
      the elbow is 1.5 times the diameter of the fabric duct. All gores shall be continuous metal
      or use fully welded joints/seams. Die stamped sheet metal elbows shall be fully welded
      on the heel and throat by an automated welder. Flexible duct elbows or adjustable gore
      type elbows are not allowed.
   2. Construct long radius elbows with centerline not less than 1.5 times the duct width.
      Shorter radius elbows may be used where required to fit in restricted spaces with prior
      approval or where shown on the drawings.
2.6 DIFFUSERS, GRILLES AND REGISTERS

A. All diffusers, grilles, and registers shall be selected to provide proper air distribution for the intended occupant application. All supply air devices shall be selected to provide a maximum air velocity of 50 ft/min at three feet above the floor, unless otherwise noted. Manufacturer’s representative shall carefully review Architectural and Mechanical drawings and ensure diffuser/grille/register selections will provide proper air distribution at NC 25 or less. Manufacturer at no additional expense to the Owner shall replace diffusers, grilles, and registers not providing proper distribution or excessive noise at scheduled airflow.

B. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper where individual duct mounted balancing dampers are not provided.

C. Refer to schedule on drawings for sizes, capacities and patterns.

D. Manufacturers: Titus, Krueger, Price, Metal Aire, Nailor, Anemostat, Carnes, Tuttle&Bailey, or equal.

2.7 FLEXIBLE DUCTWORK

A. Pre-insulated flexible round ductwork, minimum one-inch thick, Class 0 or Class 1, may be utilized for final connections to each air outlet and inlet, unless shown otherwise on the plans. Uninsulated flexible ductwork, flexible PVC or flexible aluminum duct products are not allowed. Duct shall have a minimum R-4.2 (one-inch thick) for ductwork enclosed in conditioned spaces and R-8.0 (two-inch thick) for ductwork installed in unconditioned spaces. Maximum length of flexible ductwork in each low-pressure branch shall not exceed five feet (5’) and maximum flexible connector lengths shall not exceed five feet (5’).

B. All connections shall utilize welded conical tees, aluminum conical fitting, or manufacturer high efficiency branch take-offs. Spin-in type or other types of butt tees, bullhead tees or straight taps ARE NOT permitted. Manufacturers: Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO, or equal.

C. Dampers regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

D. Flexible ductwork for low pressure systems with positive static pressure up to 2” w.g. positive pressure and negative pressured up to 1/2” w.g. suitable for both terminal unit connection and diffuser/grilles. Flexible ductwork fittings may be used at seismic expansion joints and to accommodate vertical drift between building levels. Fabrication shall include a multiple laminate of aluminized polyester/mylar, fiberglass insulation, and polyester, mechanically locked to galvanized steel helix without adhesives, exterior fiberglass insulation and fire-retardant polyester/mylar outer jacket. Manufacturers: Casco #L-181M, Flexmaster #Type 5B, Thermaflex #M-KC or EverClean, or equal.

E. Flexible Duct Clamps/Draw Bands: Stainless steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes up to 18 inches to match duct size. Use permanent screwed attachment systems for ducts sizes larger than 18”.
2.8 DUCTWORK SPECIALTIES

A. General: Where specifically called for, materials for use in fabricating ductwork specialties shall be identical to that used to fabricate ductwork. See drawings and Part 3, Execution for schedule.

B. Flexible Connections (Indoor Applications):
1. Provide flexible connectors at the discharge and inlet of fans, air handlers, rotating mechanical equipment, and where shown on the Drawings for proper vibration isolation.
2. Neoprene (polychloroprene) impregnated glass cloth with 24-gauge (minimum) galvanized metal frame. Hypalon, teflon or silicone coated fabrics may be acceptable.
3. Shall be airtight, watertight and fire retardant.
4. Minimum density of 30 oz. per sq. yard.
5. Temperature range: -40°F to 200°F
7. Neoprene-only connectors are not allowed due to non-compliant surface-burning characteristics.
8. Minimum dimensions shall be 3” metal, 3” fabric, 3” metal up to maximum dimensions of 4” metal, 6” fabric, 4” metal as required by application.

C. Volume and Splitter Dampers: Galvanized sheet metal blade and frame with Ventfabrics Inc., Ventlok operating hardware. For accessible dampers, provide #641 self-locking dial regulators and #644 self-locking dial regulators for insulated ductwork, #637 square end bearing, and #635 spring end bearing, as applicable. For inaccessible dampers, provide #666 or #677 concealed locking damper regulator with bearings as above. For static pressures above 3"wg, provide #640 HiVel dial regulator and #609 HiVel end bearing for accessible dampers. Regulators shall extend to and through ceiling with neatly installed hardware at the finished ceiling. For inaccessible dampers requiring adjustment through diffusers use Young Regulator, Bowden cable control system.


E. Ducts Through Roof: Unsupported duct penetration through a roof, without roof curbs, shall be 16-gauge (minimum), flashed and counterflashed, and provided with storm collars to secure a watertight construction.

F. Bird/Insect Screens: 19-gauge (0.91 mm) galvanized after weld wire mesh (minimum gauge), 1/2” x 1/2” openings (maximum) set in a galvanized steel frame. Or, 23-gauge (0.57 mm) galvanized after weld wire mesh (maximum gauge), 3/8” x 3/8” openings (minimum) set in a galvanized steel frame. Verify minimum requirements per local code for outdoor air intake and exhaust outlets.

G. Seismic Duct Connector (Indoors): Provide flexible connector at penetrations between two structural elements where the structural design has designated allowable seismic or settlement movement. Flexible EPDM elastomeric fabric bonded to a 1/4” steel perimeter flange on each end. EPDM shall be rated for maximum temperature of 250°F and 3 psi maximum. Connector shall be rated to meet or exceed structural design requirements with a minimum of 3” for axial compression, 3” axial extension, and 3” lateral deflection. Manufacturers: Mercer Rubber Co #ME-3/MI-9-3, Mason Industries #MD-4/MI-9, Flexicraft, Garlock, Hyspan, or equal.
H. Hanging Cables with Adjustable Fastener: Wire rope hangers for maximum point loads not exceeding 100 lbs. (45 Kg) for supporting rigid galvanized ductwork not exceeding 18” (450 mm) diameter, and suspended diffusers/grilles/terminal units. Alternate to metal strap options per SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible".
   1. Wire Rope: High tensile steel wire rope, to ASTM 1023/1023M, class A zinc coating; 7 by 7 or 7 by 19 cross-sectional construction; having a tensile strength of 256,000 psi (1,770 N per sq. mm); lengths, diameters, and wire construction to accommodate design loads and as indicated on Construction Shop Drawings.
   2. Adjustable Fastener: Mild steel (type EN1A), bright zinc plated, one-channel body; encasing a series of Type 302 stainless-steel springs with serrated self-locking grade 40 chrome steel balls, adjustable by means of an integrated mechanism, capable of accommodating load of 100 lbs. (45 kg) (maximum per hanger).
   3. Manufacturers: Gripple #Standard No. 2/3/4/5, Ductmate #Clutcher, or equal.

2.9 ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct," Access doors shall be insulated hollow core double construction. Access doors in exhaust ducts shall be of same, or heavier, gauge material as duct in which installed.

B. Casing Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 9-16, "Casing Access Doors." Access doors shall be insulated hollow core double construction of same, or heavier, gauge material as duct in which installed.

C. Minimum door size shall be 12” by 12” for simple manual access and up to 24” by 24” where personnel must pass through infrequently. Provide 20” x 54” (minimum) door for access to filters and more frequent maintenance.

D. Maximum door leakage shall not exceed 10 cfm/sq.ft. at maximum operating pressure. Doors larger than four sq.ft. in area shall open against pressure.

E. Doors:
   1. Double wall, rectangular.
   2. Galvanized sheet metal with insulation fill and gauge thickness as indicated for duct pressure class. Minimum 1” insulation thickness for doors up to 24” tall and 2” thick insulation for larger door assemblies as required per energy code. Insulation not required in exhaust duct access doors as allowed by local code.
   3. Latches: Steel cam or lever type. Access doors shall openable by hand with no tools.
   4. Vision panel shall be provided on doors 24” x 60” and larger.
   5. Fabricate doors airtight and suitable for duct pressure and air leakage class.
   6. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets for doors up to 24” tall. For larger doors provide 1-1/2” by 1/8” flat stock or 14-gauge angle frame.
   7. Gaskets: Closed cell neoprene rubber, 1” x 1/4” (minimum).
   8. Access Door Manufacturers (Small Dimensions, Low Pressure Rating): CESCO, Pottorff, Ruskin, Vent Products, Air Balance Inc., Ductmate Sandwich, United Enertech, or equal, as required by size and pressure application.

F. Hinges and Latches:
   1. Access doors up to 14 by 14 inches (300 x 300 mm) square: Two hinges or continuous piano hinge and one sash lock. Doors shall not be removable.
2. Access doors up to 16 by 24 inches (400 by 600 mm) square: Two hinges or continuous piano hinge and two sash locks (minimum). Doors shall not be removable.

3. Access doors up to 24 by 48 inches (600 by 1200 mm): Three hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.

4. Access doors larger than 24 by 48 inches (600 by 1200 mm): Four hinges or continuous piano hinge and two compression latches (minimum) with outside and inside handles.

5. Latch Manufacturer: Venlok #100 Series hinges and latches on low pressure system doors up to 18” maximum dimension, #200 Series on larger low pressure system doors, #333 Series on high pressure systems with stops, or equal.

2.10 DUCTWORK SEALANT

A. Duct tape, pressure sensitive type, is not allowed.

B. Solvent-based and oil-based sealants are not allowed indoors.

C. Seal all transverse joints, including mechanical joint flanges, similar to Ductmate, on all supply, return, exhaust, and outside air intake ducts.

D. All sealant systems for outdoor application to be suitable for use in exposure to water, sunlight, temperatures extremes associated with project location.

E. All sealant systems for indoor application to be meet VOC limits as specified in South Coast Air Quality Management District (SCAQMD) Rule #1168 limiting VOC’s to 80 grams/liter for duct liner adhesives and 250 grams/liter for duct sealants.

F. Indoor Application Water-Based Joint and Seam Sealant:
   1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
      a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
      b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
      c. Flexibility on 1/4” mandrel.
      d. Freeze/thaw stability - 5 cycles.
      e. Service temperature: -20°F to +200°F (-29°F to +93°C).
      f. ASTM 5590: Resistance to mold, mildew and water.
      g. Meet all SMACNA seal classes.
      h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10” water gauge.
   2. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal, Ductmate #PROseal, Design Polymerics #DP1010 or #DP1020 or #DP 1010 Spray, or equal.

G. Indoor Application Water-Based Joint and Seam Sealant with Extended Material Warranty:
   1. Flexible, adhesive sealant, suitable for high velocity and high pressure applications, UL 181B-M listed, UL 723 classified, and complying with NFPA requirements for Class 1 ducts.
      a. Sealant shall be water based latex UL 181 B-M non-reinforced sealant.
      b. Sealant shall meet flame spread rating of 0 and smoke developed rating of 0.
      c. Flexibility on 1/4” mandrel.
      d. Freeze/thaw stability - 5 cycles.
      e. Service temperature: -20°F to +200°F (-29°F to +93°C).
      f. ASTM 5590: Resistance to mold, mildew and water.
      g. Meet all SMACNA seal classes.
      h. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, 6, and 10” water gauge.
i. Manufacturer: Carlisle (Hardcast) #Iron Grip 601 or #Flex-Grip 550 or #Spray-Seal and #Aluma-Grip AFT-701 rolled sealant, or equal.

2. And, all transverse joints, longitudinal seams, and duct wall penetrations shall be sealed by a 30-mil rolled sealant. Rolled sealant shall be comprised of a 2-mil foil faced with 28 mils of butyl adhesive/sealant conforming to the product specifications. Rolled sealant shall have the following physical properties:
   a. Peel Strength: 16 lbs. per linear inch.
   b. Tensile strength: 955 psi
   c. Elongation: 560%
   d. Bonding time: Instant with full bond in 24 hours.
   e. Resistance to mold, mildew and water.
   f. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
   g. Service temperature: -20°F to +200°F (-29°C to +93°C).
   h. Surface burning characteristics: Flame spread/smoke developed rating of 20/40, tested in accordance with UL 723.
   i. VOC: 0 g/l
   j. Meet all SMACNA seal classes.
   k. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, and 6” water gauge.
   l. Manufacturer: Carlisle (Hardcast) #Aluma-Grip AFT-701 rolled sealant, or equal.

H. Rolled (Tape) Mastic Sealant for indoor and outdoor application on flat sheet metal duct joints. Aluminum substrate with modified butyl sealant. Compliant with UL 181B-FX. Rolled sealant shall have the following physical properties:
   a. Peel Strength: >10 lbs. per linear inch.
   b. Bonding time: Instant tack with full bond in 24 hours.
   c. Resistance to mold, mildew and water.
   d. Weather Resistance per ASTM G-53 @ 2000 hours QUV.
   e. Service temperature: -20°F to +180°F (-29°C to +82°C).
   f. Surface burning characteristics: Flame spread/smoke developed rating of 5/25, tested in accordance with UL 723.
   g. VOC: 0 g/l.
   h. Meet all SMACNA seal classes.
   i. Meet all SMACNA pressure classes (+/-): 1/2, 1, 2, 3, 4, and 6” water gauge.
   j. Roll width as required to maintain minimum 3/4” adhesion width on each side of joint.
   k. City of Los Angeles RR#8069 approved.
   l. Manufacturer: Carlisle (Hardcast) #Foil-Grip 1404-181BFX rolled sealant, or equal.

I. Manufacturers of duct sealant systems for various ductwork applications: Design Polymerics, Tremco, Dure Dyne, Carlisle Hardcast, Ductmate, Mon-Eco Industries, Sikaflex, and McGill AirSeal LLC.

2.11 PLENUMS AND EQUIPMENT CASINGS

A. Construct casings and plenums in conformance with SMACNA. Minimum Pressure Class: Unless otherwise indicated construct plenums and casings to withstand either a negative or positive static pressure of 4” w.g.

B. Single-Wall: Provide single-wall, casings and plenums where indicated on the drawings.
   1. Construct in accordance with SMACNA Standards.
   2. Use steel-angle-reinforced standing-seam construction.
   3. Locate intermediate bracing angles bolted to the casing 24 inches on centers.
   4. Construct for static pressure indicated or for the maximum fan static pressure whichever is less.
5. Bolt to 3” high concrete pads using 1-1/2” x 1-1/2” x 1/4” thick galvanized steel structural sections.

C. Double-Wall: Provide double-wall insulated ductwork where indicated on the drawings.
   1. Construct in accordance with SMACNA Standards. Provide insulation thicknesses to meet or exceed the minimum required by local energy codes.
   2. Provide 2” (minimum) thick prefabricated double wall insulated metal panel assemblies, with 16-gauge aluminum or 18-gauge minimum galvanized steel outer sheets.
   3. Provide 22-gauge galvanized steel inner sheets to encapsulate the insulation.
   4. Casings shall be fully metal enclosed, insulated with 2” thick (minimum) rigid fiberglass insulation and conforming to NFPA 90A, with maximum flame spread of 25 and maximum smoke developed of 50.
   5. Field or factory fabricate to size and configuration indicated on the drawings, using field verified dimensions.
   6. Provide coordinated shop drawings.
   7. Reinforce spans 10’ or greater with structural steel sections to yield maximum deflection 1/4” at minus 10” w.g. or plus 10” w.g. static pressure.
   8. Provide openings and doors, all factory framed, and reinforced with 304 stainless steel structural sections.
   9. Construct doors of same material as casings, of sizes and locations indicated on the drawings but not smaller than 18” by 54”, and conforming to SMACNA.
  10. Provide doors, hinges and hardware factory fabricated and mounted.
  11. Door swings shall open against air pressure, with door latches operable from either side.
  12. Provide door seals with neoprene gaskets, which have an airtight seal.
  13. Provide each door with a 10” by 10” wire reinforced double pane window.
  14. Bolt base channel to 3” high concrete pads.

2.12 CONTROL DAMPERS

A. General: Low leakage dampers shall be Class 1A with a maximum leakage rate of 3 cfm/ft² at 1.0 in wg pressure difference when tested to AMCA Standard 500.

B. Damper Type One: Airfoil Low Leakage Dampers (Galvanized Steel or Aluminum)
   1. Application: Commercial supply, return, and general exhaust air systems up to 3,000 fpm velocity. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.
   2. Frames to be 5” x 1” x 16-gauge galvanized steel hat-shaped channel or 5” x 1” x 0.125 anodized extruded aluminum hat channel with corner reinforcement.
   3. Blades: Airfoil shaped, single piece, 6” wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
      a. Action:
         1) Parallel blade for open and closed control, and economizer dampers.
         2) Opposed blade for modulating and air flow measurement control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 7/16” diameter steel (minimum), hex-shaped, mechanically attached to blade.
   7. Linkage to be concealed in frame.
   8. Crank lever for operator to be provided.
   9. Provide with mill finish on blades and frame.
  10. Damper position indicator switch(es) as required by control sequence.
  11. Manufacturer: Ruskin #CD60 or #CD50, Swartout, NCA PBD/OPD-AF-101, American Warming, Tamco, Air Balance, Greenheck, Pottorff, Nailor or equal.
C. Damper Type Two: Airfoil Low Leakage for Coastal and High Moisture Environments (Aluminum)
   1. Application: Commercial supply, return, and general exhaust air systems where damper will be exposed to damp marine air and where velocity is less than 3,000 fpm. Damper shall be rated for -22°F to 122°F (-30°C to 50°C) minimum operating range.
   2. Frame to be 5" x 1" x 0.125 anodized extruded aluminum hat channel with silicon side seals and corner reinforcement.
   3. Blades: Airfoil shaped, single piece, 6" wide (maximum), 6063-T5 anodized aluminum. a. Action:
      1) Parallel blade for open and closed control, and economizer dampers.
      2) Opposed blade for modulating and air flow measurement control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 1/2" diameter steel, hex-shaped, mechanically attached to blade.
   7. Linkage to be concealed in frame.
   8. Stainless steel hardware.
   9. Damper position indicator switch(es) as required by control sequence.
  10. Manufacturer: Tamco #SW Series, Ruskin #CD50, Swartout, NCA, Pottorff, American Warming, Air Balance, Greenheck or equal.

D. Damper Type Three: Heavy Duty Fan Discharge Control
   1. Application: Velocity over 3,000 fpm as fan outlet damper.
   2. Frames to be 8" x 2" x 12-gauge steel channel (minimum).
   3. Blades to be 8" wide (maximum), 0.080 thick extruded aluminum airfoil design.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 3/4" diameter steel, hex-shaped, mechanically attached to blade.
   7. Linkage to be out of airstream with 10-gauge galvanized steel clevis type arms with crank lever operator.
   8. Provide with mill finish on blades and frame.
   9. Maximum temperature rating to be 300°F.
  10. Manufacturer: Ruskin #CD102, Nailor, Swartout, Pottorff, American Warming, Air Balance, Greenheck or equal.

E. Damper Type Four: Low Leakage Airfoil Insulated Dampers
   1. Application: Air handler intake and exhaust. Damper shall be rated for -25°F to 180°F (-32°C to 83°C) minimum operating range.
   2. Frames to be 5" x 1" x 16-gauge galvanized steel hat-shaped channel or 5" x 1" x 0.125 anodized extruded aluminum hat channel with corner reinforcement.
   3. Blades: Insulated, single piece, 6" wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum, R-3.3. a. Action: Parallel blade for open and closed control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 7/16" diameter steel (minimum), hex-shaped, mechanically attached to blade.
   7. Linkage to be concealed in frame.
   8. Crank lever for operator to be provided.
   9. Provide with mill finish on blades and frame.
  10. Damper position indicator switch(es) as required by control sequence.
  11. Manufacturer: Ruskin #IL35, Greenheck, Pottorff, Tamco, or equal.
F. Damper Type Five: Ultra Low Leakage Airfoil, Double Row Dampers
   1. Application: Natural ventilation wall inlets and outlets with parallel (double row) damper blades. Damper shall be rated for -72°F to 275°F (-58°C to 135°C) minimum operating range.
   2. Frames to be 8” x 1” steel or aluminum channel thermally broken with insulation within frame channels.
   3. Blades: Airfoil shaped, single piece, 4” wide (maximum), 14-gauge galvanized steel or 6063-T5 anodized aluminum.
      a. Action: Parallel blade for open and closed control.
   4. Seals: Silicone rubber or EPDM blade and jam seals.
   5. Axles: 7/16” diameter steel (minimum), hex-shaped, mechanically attached to blade.
   7. Linkage to be concealed in frame
   8. Crank lever for operator to be provided.
   9. Provide with mill finish on blades and frame.
  10. Damper position indicator switch(es) as required by control sequence.
  11. Manufacturer: Ruskin #CD40x2, Greenheck, Pottorff, Tamco, or equal.

2.13 BACKDRAFT AND RELIEF DAMPERS

A. Light Duty Counterbalanced Backdraft Damper
   1. Applications: Low pressure ductwork systems, including outside air intake and exhaust locations.
   2. Frame: Extruded aluminum channel frame with flanges to match ductwork requirements.
   3. Blades: Parallel blades, horizontal orientation, 0.025” (0.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
   4. Counterbalance: Adjustable steel weights mechanically attached to blade.
   5. Mounting: Vertically or horizontally oriented as shown on the drawings.
   6. Sized for maximum velocity of 1,500 fpm (7.6 m/s).
   7. Maximum back pressure of 2.0” w.g. (1.1 kPa).
   8. Maximum Pressure Drop Fully Open: 0.06” w.g. (15 Pa).
   9. Manufacturer: Ruskin #CBD2, Greenheck #WD Series, or equal.

B. Heavy Duty Counterbalanced Backdraft Damper
   1. Application: Medium pressure air ductwork and generator exhaust.
   2. Frame: Galvanized steel, 16-gauge (1.5 mm) wall thickness minimum with flanges to match ductwork requirements.
   3. Blades: Parallel blades, horizontal orientation, 0.05” (1.2 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.
   4. Counterbalance: Adjustable steel weights mechanically attached to blade.
   5. Mounting: Vertically or horizontally oriented as shown on the drawings.
   6. Sized for maximum velocity of 2,500 fpm (12.7 m/s).
   7. Maximum back pressure of 4.5” w.g. (1.1 kPa).
   8. Maximum Pressure Drop Fully Open: 0.20” w.g. (50 Pa).
   9. Manufacturer: Ruskin #BD6, Greenheck #HB Series, Nailor #1380, or equal.

C. Barometric Relief Damper
   1. Applications: Gravity hood exhaust, room pressurization control and stairwell pressurization relief.
   2. Frame: Extruded aluminum channel frame, 0.090” (2.3 mm) wall thickness minimum with flanges to match ductwork requirements.
3. Blades: Parallel blades, horizontal orientation, 0.063” (1.6 mm) minimum formed aluminum. Maximum 6” wide blades. Extruded vinyl blade seals mechanically attached to blade edge.

4. Counterbalance: Adjustable on-blade counterweights for tuning of start-to-open and full open blade operation.

5. Axle: 3/8” (9.5 mm) galvanized steel rod with roller bearings.

6. Mounting: Vertically or horizontally oriented as shown on the drawings.

7. Sized for maximum velocity of 1,000 fpm (5.1 m/s).

8. Maximum back pressure of 2.0” w.g. (0.5 kPa).

9. Start-Open Pressure: 0.05” w.g. (12.5 Pa).

10. Manufacturer: Greenheck #BR-30 for vertical mounting, Greenheck #BD-10 for horizontal mounting, or equal.

D. Round Counterbalanced Backdraft Damper

1. Dampers shall be of the two-blade design with separate axles. Blades shall be retained in closed position with tensioned spring and field adjustable for required opening pressure. Not allowed for installation in dryer exhaust, kitchen exhaust or bypass air applications.

2. Frame: 20-gauge (1.0 mm) minimum galvanized steel.

3. Blade: 0.016” thick (0.40 mm) minimum aluminum.


5. Axle: 3/16” (4.8 mm) minimum steel.

6. Maximum Velocity: 1,000 fpm (7.6 m/s).

7. Maximum Pressure Drop Fully Open: 0.06” w.g. (125 kPA).

8. Manufacturer: Ruskin #BDR2, Greenheck #WDR-53 or equal.

E. Light Duty Non-Counterbalanced Neoprene Backdraft Damper

1. Applications: Low pressure exhaust from small mechanical equipment less than 2,500 cfm.

2. Frame: 16-gauge galvanized steel with flanges to match ductwork requirements.


4. Mounting: Vertically or horizontally oriented as shown on the drawings.

5. Sized for maximum velocity of 1,000 fpm (5.1 m/s).

6. Manufacturer: Ruskin #NMW2 or equal.

2.14 FAN POWERED BOXES

A. Furnish and install fan powered boxes of the type, sizes and capacities shown on the Drawings.

B. Casing: 22-gauge galvanized steel casing with rectangular discharge with slip and drive type connection. One-piece aluminum backdraft damper provided on fan discharge. Damper factory set and aligned for precise seal. Leak rate 2% at 0.5 w.g.

C. Cabinet shall be internally insulated with liner that prevents fibers from entering the air stream.

1. Insulation liner shall be 3/4” thick (minimum) or greater. Refer to schedule on drawing for additional requirements that may be more restrictive.

2. Insulation types include, but are not limited to, the following:

   a. Fiberglass or mineral wool acoustical duct liner bonded with a bio based thermosetting resin mat fiber-free facing.

   b. Fiberglass or mineral wool insulation with a foil or sheetmetal facing.

   c. Elastomeric or polyimide foam insulation with acrylic polymer airstream coating.
d. Natural (denim or recycled) fiber with bio based thermosetting resin mat fiber-free facing, foil facing or sheetmetal facing.

3. Refer to Section 230713 “Duct Insulation” for additional requirements.


5. K-value: 0.25 Btu•in./(hr•ft²•°F) at 75°F (maximum).


7. Smoke developed index: ASTM E84, less than 50.

D. The control device shall be designed to maintain consistent flow measurement regardless of inlet flow deflection. Angled duct inlets, at 90° or less to the control device, shall not alter the maximum or minimum factory setting by more than 10%. The assembly shall incorporate a multi-point averaging differential pressure sensor mounted on the inlet.

E. Air Valve: Galvanized steel or cylindrical die cast aluminum airflow control device. Valve tapered to fit standard round flexible duct diameters. Normally open sequencing for reverse acting thermostat. Leak rate 4% at 2” w.g. Integral flow ring taps, calibration chart for flow measurement, ±10% accuracy regardless of inlet condition.

F. Fan: Fan style galvanized steel wheel. Housing is 18-gauge steel and fan board is 16-gauge steel.

G. Motor to be an Electrically Commutated Motor (ECM) with a minimum efficiency of 70% throughout the operating range. Motor speed to be controlled for a constant delivery fan cfm regardless of varying external static pressure. Provide remote adjustment option for integration with DDC controls by others.

H. Fan Controls: Factory mounted on-off toggle switch, for disconnect and normally open P.O. switch to energize fan.

I. Disconnect Switch: Provide factory mounted fused disconnect switch with interlocking door handle on terminal box door.

J. Dust Cover: Integral control panel shall be gasketed for tight seal.

K. Hot Water Coil: Where scheduled on drawings, provide a single or double row hot water heating coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed 0.35” w.g. for a double row coil or 0.20” w.g. for a single row coil. Coil shall be pressure tested to 200 psig.

L. Chilled Water Coil: Where scheduled on drawings, provide a single or double row chilled water cooling coil with aluminum fins mechanically bonded to copper coils. Coil velocity shall not exceed 700 FPM and static pressure loss shall not exceed 0.35” w.g. for a double row coil or 0.20” w.g. for a single row coil. Coil shall be pressure tested to 200 psig.

M. VAV Control: Factory mounted and piped to pneumatic or electronic actuator. Regulator is thermostatically reset with velocity controller, which provides constant delivery air control within ±10% accuracy regardless of inlet condition. The velocity signal is input to the volume regulator, which will automatically adjust valve position to compensate for either increase or decrease in duct pressure. Adjustable set points provided to set maximum and minimum cfm. Reverse acting control sequence must be used. Bleed rate 25 scrim. Integral flow ring taps and calibration chart shall be provided on unit.

N. Manufacturer: Price, Nailor or equal.
PART 3 EXECUTION

3.1 DUCTWORK GENERAL REQUIREMENTS

A. Fabricate ducts with galvanized sheet steel, except as otherwise indicated and as follows:
1. All duct system appurtenances are to be the same material as ductwork including volume dampers and access panels.
2. Where duct joints are not connected using flanges or manufactured assemblies, provide sheet-metal screws equally spaced around the joint or equivalent fastening method as required by mechanical code and SMACNA HVAC Duct Construction Standards-Metal and Flexible. Where sheet-metal screws are utilized provide a minimum of three screws on round ductwork and minimum four screws on rectangular ductwork. Maximum spacing between screws shall not be greater than 12” on center.
3. Laser cutter & soldering exhaust:
   a. Material: Type 316L stainless steel, minimum 18-gauge ductwork and fittings.
   b. Joints: TIG welded. Weld may be either butt-weld or swaged joint with lap weld with lap running in direction of airflow. Welding rod shall be type 316L material. MIG welding technique not allowed. Inert gas purging inside ductwork not required.
   c. Flanges: Manufactured 309 stainless steel clamp and frame.
   d. All accessories shall be 316 stainless steel including dampers, air valves, damper hardware, etc.
   e. Pressure testing: Refer to pressure classification and testing procedure table this specification section.
4. Magnetically or Electrically sensitive rooms, including MRI rooms:
   a. All ductwork, fittings, grilles/diffuser, screws, etc, shall be constructed of aluminum in and around magnetically/electrically sensitive rooms. Refer to all construction documents for location of these critical rooms.

3.2 DUCTWORK CONSTRUCTION AND SEALING CRITERIA

A. Leakage classification of ductwork shall conform to the minimum requirements of Table 3.1 and Table 3.2 (see below) based on procedures of “SMACNA HVAC Duct Construction Standards-Metal and Flexible” and “SMACNA HVAC Air Duct Leakage Test Manual” as follows:

<table>
<thead>
<tr>
<th>TABLE 3.1</th>
<th>DUCT LEAKAGE CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUCT WORKING PRESSURE CLASS</td>
<td>AIR PRESSURE LESS THAN +/-0.5”WC</td>
</tr>
<tr>
<td>SMACNA Seal Class</td>
<td>C</td>
</tr>
<tr>
<td>Sealing Applicable</td>
<td>Transverse joints</td>
</tr>
</tbody>
</table>

LEAKAGE CLASS

| Rectangular sheet metal SMACNA Leakage Class | 6 | 6 | 4 |
| Round sheet metal SMACNA Leakage Class | 6 | 4 | 2 |

Note: Duct sealant ranges and classification are generally more restrictive than SMACNA guidelines.
B. Ductwork shall be constructed to SMACNA pressure class based on 150% of the maximum working pressure at connection to air handling unit, or better as specified herein. Unless called out otherwise on drawings the pressure classification of ductwork shall be as follows:

<table>
<thead>
<tr>
<th>DUCT SYSTEM</th>
<th>LOCATION</th>
<th>WORKING PRESSURE (ESP FROM SCHEDULE)</th>
<th>BUILD TO SMACNA PRESSURE CLASS</th>
<th>BUILD TO SMACNA SEAL CLASS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low pressure supply air</td>
<td>Downstream of air terminal units to grilles, registers or diffusers.</td>
<td>+0.5&quot;</td>
<td>+1&quot; wc</td>
<td>B</td>
</tr>
<tr>
<td>Transfer air</td>
<td>From grille to grille, or acoustic boots or “Z” bends</td>
<td>+/-0.25&quot; wc</td>
<td>+/-0.5&quot; wc</td>
<td>C</td>
</tr>
<tr>
<td>Med pressure supply air</td>
<td>From AHU to air terminal units</td>
<td>+2&quot; wc</td>
<td>+3&quot; wc</td>
<td>A</td>
</tr>
<tr>
<td>General exhaust</td>
<td>From grille to exhaust fan</td>
<td>-4&quot; wc</td>
<td>-5&quot; wc</td>
<td>A</td>
</tr>
<tr>
<td>General Exhaust</td>
<td>From Exhaust fan to duct main</td>
<td>+2&quot; wc</td>
<td>+3&quot; wc</td>
<td>A</td>
</tr>
<tr>
<td>General exhaust</td>
<td>From grilles to exhaust main</td>
<td>-1&quot; wc</td>
<td>-2&quot; wc</td>
<td>A</td>
</tr>
</tbody>
</table>

3.3 DUCTWORK LEAKAGE TESTING

A. Refer to Section 230593 Testing, Adjusting and Balancing for air leakage testing requirements and procedures.

3.4 DUCTWORK SPECIALTIES INSTALLATION

A. Ductwork is generally diagrammatically indicated and shall be generally installed as indicated. Do not scale Drawings for exact location of ducts. Install ducts to best suit field conditions and cooperate with other trades. Do not penetrate Structural members without consent of Architect or Structural Engineer. Check with Structural drawings prior to locating any penetrations. Duct sizes are indicated as net inside dimensions on the Drawings. The indicated dimensions shall be altered at the job site for the purpose of avoiding interferences and clearance difficulties to other dimensions producing the same air handling characteristics, provided such altered dimensions are approved by the Architect. Ducts shall be constructed in accordance with the latest edition of codes and standards identified in Part 1 and as shown on the Drawings.

1. Grilles, Registers and Diffusers: Install flush, squared, tightly sealed, and entirely covering sheet metal ductwork and gaskets. Thread sheet metal mounting screws tightly into sheet metal. All frames shall be selected to fit the ceiling type. Verify with Architectural Drawing. Each diffuser, grille and register shall be individually capable of balancing via duct mounted balancing dampers or attached opposed blade dampers. Provide unit opposed blade damper only where individual duct mounted balancing dampers are specifically noted as not provided. Duct connections shall fit securely to necks or collars behind face area. Provide all necessary transition pieces and duct collars to make connections from ductwork to neck sizes. Where ducts connect directly to necks or collars provide a minimum straight duct section of two times the duct diameter.
to the last elbow. Where minimum straight duct sections are not physically possible provide sheet metal plenum sized for approximately 500 fpm air velocity with duct tapped directly to side of plenum. Where building walls, floors and ceilings form portions of duct or plenum, provide gasketed angles or channels at junction points, securely bolted and sealed to building structure.

2. Install turning vanes in all mitered elbows in all ducts, so that tips are parallel with the sides of the ducts. Tips of acoustical turning vanes on outside radius shall be flush with acoustical lining.

3. Provide flexible connections to completely isolate fans from direct contact with all sheet metal work.

4. Provide access doors, as required, for access to valves, controllers, dampers and humidifier dispersion tubes. Access doors required in Product Conveying Vapor/Moisture Ductwork (see applicable paragraph above) shall not be installed in the bottom of the duct or in a manner to allow leaks.

5. Volume Dampers: Provide manual volume dampers in all supply, return and exhaust branch and run-out ductwork to grilles, diffusers, registers, and other inlet and outlet openings to facilitate balancing of air distribution systems. These are to be provided as part of contract whether shown on plans or not. Where ceilings are not accessible, provide access door or remote damper regulator. Volume dampers must be installed immediately downstream of each duct takeoff.

6. Multi-Blade Control Dampers: Provide control dampers as shown on drawings. Coordinate with BAS system provider for control actuators.

7. Splitters and splitter dampers shall not be installed in medium or low pressure supply ductwork to VAV systems.

8. Clean and pretreat surfaces before application of sealant. Conform to the manufacturer's cleaning procedures. Install sealants in conformance with manufacturer's instructions.

9. Except where noted, vertical ducts or horizontal ductwork penetrating fire rated ceilings, roofs, walls and floors shall be fire separated with UL listed and labeled fire dampers installed per UL tested assembly including sleeves and retaining angles. Provide additional fire dampers indicated on the Drawings and as otherwise required by the IBC and building inspector. Provide approved firestopping between damper frames and firewalls. Install fire dampers in accordance with NFPA Standards, requirements of the State Fire Marshal, and applicable codes. Ensure that fire dampers are installed in the open position.

10. For penetration of fire rated partitions which meet the IBC Chapter Seven requirements of non-Group H occupancy penetration of tenant separation and corridor walls in buildings with fire sprinklers provide metal sleeves as follows: A minimum 12 inch-long (0.30 m) by 0.060-inch-thick (1.52 mm) steel sleeve shall be centered in each duct opening. The sleeve shall be secured to both sides of the wall and all four sides of the sleeve with minimum 1-1/2" by 1-1/2" by 0.060-inch steel retaining angles. The retaining angles shall be secured to the sleeve and the wall with No. 10 screws. The annular space between the steel sleeve and wall opening shall be filled with rock wool batting on all sides.

B. Hangers and Supports: Securely fasten all ductwork to the building construction by means of hangers, supports, guides, anchors, and sway braces to maintain duct alignment, to prevent sagging, and to prevent noise and excessive strain on ductwork due to movement under operating conditions.

1. Maximum spacing between hangers shall not exceed ten (10) feet for rectangular sheet metal ductwork and twelve (12) feet for spiral round sheet metal ductwork. Provide hanger at each change in direction and at each branch takeoff. Refer to “SMACNA HVAC Duct Construction Standards Metal and Flexible” for additional requirements.

2. Provide duct supports within two (2) feet of each: duct elbow; connection to flexible ductwork; connection to terminal units; connection to fan coil units; connection to exhaust fans, connection to air handling units, and fire and/or smoke dampers.
3. Adequately mount and anchor all material and equipment as required. Include lateral bracing as required to prevent horizontal, seismic movement. Refer to IBC and Architectural and Structural Drawings for seismic requirements.

4. Do not support ductwork from other ducts, pipes, fans or any other pieces of equipment.

5. Powder driver fasteners shall not be used to support rectangular ducts larger than 40" maximum dimension. Powder driven fasteners shall not be allowed in existing facilities.

6. Support round duct, larger than 36", shall have two hangers at each support point.

7. Hangers and supports shall conform to SMACNA section "Hangers and Supports". Nail inserts, hangers and supports to formwork before slabs are poured. Cut off or remove nails, strap-ends and other projections, flush with concrete after forms are removed.

8. Support vertical ducts, passing through floors with two continuous angles screwed to the duct and bearing to the floor and conforming to SMACNA section "Riser Support-From Floor". Blocking or Shimming ducts will not be permitted.

C. Other:

1. Fans: Align fans, motors, and drives. Install fans to render bearings accessible for lubrication without dismantling fans or ducts. Provide extended bearing oilers as required. Mount all fans on vibration isolators as specified.

2. Insulation: Properly and neatly apply insulation on all material and equipment and apparatus, as specified, including all fittings. Apply insulation over clean, dry surfaces, with adjoining sections firmly butted together and canvas smoothly pasted over. When vapor barriers are specified, install continuous overall external surfaces of the entire system.

3. Duct Sizing: Where duct sizes are not specifically shown on the plans or must be modified due to physical limitations, supply ducts may be sized at a maximum velocity of 1,500 fpm or 0.08" sp friction per 100 feet, whichever provides the larger duct, and return/exhaust/intake ducts may be sized at a maximum velocity of 1,000 fpm or 0.06" sp friction per 100 feet, whichever provides the larger duct. Refer to Basis of Design for further duct sizing criteria.

4. Humidifiers: Humidifier installation shall be approved by manufacturer and coordinated with all other systems. Condensate piping shall include p-traps as recommended by the humidifier manufacturer. Insulate exposed piping as required by the code.

5. Exterior Ductwork: Ductwork located and installed outside the building envelope, on roof, grade or other location exposed to weather, shall be constructed and sealed airtight and watertight. The top of exterior ducts shall be cross-broken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.

6. Double Wall Ductwork: Insulated ductwork located and installed outside the building envelope may be constructed of two layers of galvanized sheetmetal encapsulating the insulation layer. The inner duct shall be constructed as the main carrier duct with gauge and fabrication as required per the SMACNA Duct Construction Standards and minimum 24-guage. The insulation layer shall be provided as required by the local energy code or Section 230713 Duct Insulation, whichever is greater. The outer sheetmetal layer shall be a non-pressurized layer, minimum 24-gauge, to encapsulate the insulation layer to prevent weather degradation and optimize the insulation effectiveness for the life of the building. The top layer shall be crossbroken and sloped 1% towards edge of duct to eliminate any locations where rainwater can collect. Or, provide additional duct supports and mounting adjustments as necessary to prevent water retention on top of ductwork.

7. Access Floor Diffusers: The mounting ring for floor mounted diffusers are to be affixed to the floor tiles using a clamp insert or other method approved for use with the floor diffuser.
3.5 FLEXIBLE DUCTWORK INSTALLATION

A. Flexible insulated round ductwork connectors may be utilized where shown on the Drawings and for transitions between air handling equipment and rigid ductwork. A five (5) foot (maximum) length of flexible air duct shall be allowed to be used as an elbow at a terminal devices or air outlet/inlet, unless shown otherwise on the Drawings. No intermediate joints are allowed. Seal each end using two wraps of tape listed in accordance with UL 181B and marked 181B-FX, followed by a mechanical stainless steel screw operated drawband. Plastic drawbands are not allowed. Support duct to maintain smooth shape without sagging. All connections shall utilize welded conical tees, aluminum conical fitting, Flexmaster #CBD, or 45° boot take-offs by Flexmaster #STO. Spin-in type or other types of butt tees, bullhead tees or straight taps are not permitted. Damper regulators shall include end bearings as manufactured by DuraDyne, Ventlok or equal.

B. Flexible duct runouts to diffusers and grilles is limited to the following sizes:
   1. 6" diameter: Up to 100 cfm
   2. 8" diameter: Up to 200 cfm.
   3. 10" diameter: Up to 360 cfm.
   4. 12" diameter: Up to 600 cfm.
   5. 14" diameter: Up to 900 cfm.

3.6 EXPANSION JOINTS

A. At a non-rated penetration through an expansion joint wall:
   1. Provide insulated flexible ductwork through expansion joint. Flexible connector shall be no longer than five feet between segments of rigidly attached ductwork.

B. At a fire/smoke rated penetration through an expansion joint wall:
   1. Provide required fire/smoke damper with sleeve through rated assembly as required by Building Code and manufacturer’s instructions. Provide breakaway duct connections as required by manufacturer’s listing. Ductwork bracing on either side of wall must not be rigid within ten feet of wall to allow for building movement. Seismic restraints must not be closer than ten feet of expansion joints on either side of wall. Following a building seismic/movement event the ductwork will need to be inspected and possibly reattached to the fire/smoke damper.

3.7 STAINLESS STEEL DUCTWORK

A. For installations serving moisture, vapor, or fume exhaust.
   1. For connections to hoods or equipment provide minimum 12" length flanged and bolted stainless steel spool piece connection.
   2. All fittings shall be long radius. Round elbows shall be minimum 5-gore.
   3. Slope horizontal ductwork back toward source connected equipment minimum 1% slope so that moisture and liquids may drain back toward equipment.
   4. Low point “traps” in the ductwork shall be fitted with a low point drain valve, 1/2” welded connection, stainless steel piping and valve.
   5. All welding to be completed by certified welders experienced in 316 stainless steel.
3.8 DUCTWORK SEALANT METHODS

A. General
1. Installation shall meet or exceed all applicable federal, state and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.
2. All installation shall be in accordance with manufacturer’s published recommendations.
3. Cleanliness:
   a. Before installing sealant, Surface must be dry and be free of dirt, oil, grease, and loose or foreign matter that could impair adhesion wipe ductwork to a visibly clean condition.
   b. During construction, provide temporary closures of metal or taped polyethylene on open ductwork and duct taps to prevent construction dust or contaminants from entering ductwork system. Seal ends of ductwork prior to installation to keep ductwork interior clean. Remove closures only for installation of the next duct section.
   c. During duration of construction, maintain the integrity of all temporary closures until air systems are activated.
   d. Follow the Advanced Level requirements as found in the SMACNA Duct Cleanliness for New Construction Guidelines.

B. Installation of Mastic/Sealant Duct System
1. One Part Sealant System:
   a. Apply one-part sealant system at a 20 to 30 wet mil thickness with a brush, putty knife; caulk gun or spray to duct joints, fasteners and seams. Tool, if necessary, caulk bead with putty knife or brush. Let dry per manufacturer data sheet of a minimum of 48 hours.
2. Or, One Part Spray Applied Sealant System:
   a. Use a manufacturer approved airless sprayer capable of application pressure up to 2,000 psi spraying through a minimum 0.111 tip. Apply in a smooth application perpendicular to the substrate at a rate of 20 to 30 wet mils to joints, seams and duct wall penetrations per manufacturer’s technical data sheet. Let dry per manufacturer data sheet of a minimum of 48 hours.

C. Installation of Mastic/Sealant Duct System with 10-Year Warranty
1. Installation of Rolled Sealant Tape over Mastic/Sealant:
   a. Cut desired length for each side of the ductwork; peel off release liner and center over joint, seam or penetration. The rolled sealant should completely cover the sealant. Use hand pressure to place the rolled sealant followed by a squeegee application. Lap tape end 2 inches (50 mm minimum). Squeegee rolled sealant to insure bond and complete adhesion to the duct. Instant adhesion requires precise positioning. Not re-positional. Four-Bolt flange requires applying corner pieces prior to applying the edge strips.

D. Field Quality Control
1. Allow duct sealant system to cure minimum 48 hours before pressure testing for the fluid applied Sealants. Rolled sealants can be tested immediately with duct leakage tester.
2. Ductwork leakage testing and/or inspection shall be performed prior to installation of external ductwork insulation.
3. Notify Owner’s Representative a minimum of seven (7) calendar days in advance of leakage testing.
4. Leaks identified during ductwork air leakage testing shall be repaired by:
   b. Thorough cleaning of the joint surfaces.
c. Installation of multiple layers of sealing materials.

5. Discrepancies found during testing and balancing between duct traverses and diffuser/grille readings shall result in re-inspection, repair and retest until discrepancies are eliminated.

### 3.9 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 the 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.

### 3.10 CONTROL DAMPER INSTALLATION

A. Note that installation of control dampers is a part of the mechanical contractor’s work regardless of whether they are specified in this section or as part of products to be selected by the Control Contractor.

B. When electric actuators are provided, dampers shall be installed to allow direct over the shaft mounting of actuators. No connecting rods and stand off brackets shall be necessary.

C. Dampers shall be installed straight and true, level in all planes, and square in all dimensions. Dampers shall move freely without undue stress due to twisting, racking (parallelogramming), bowing, or other installation error.

D. Blades shall close completely. Leakage shall not exceed manufacturer’s specifications at rated static.

E. Structural support shall be provided as necessary for all multi-section dampers.

F. Where blankoffs or structural supports obstruct duct or air passages, the decrease in free area shall not exceed 15% of the damper face area unless otherwise specified here or on plans.

G. No individual damper section may exceed 20 sq. ft.

H. Dampers shall be parallel blades style for outside air economizer to facilitate improved mixing of outside air and return air. Airflows shall be directed towards each other.

I. Where ducts penetrate an exterior surface install a Class I motorized damper at each outdoor air supply opening, exhaust opening, relief outlet, shaft vent and stairway vent, as required to comply with minimum requirements of the local Energy Code.

1. Dampers shall be installed with automatic controls configured to close when the systems or spaces served are not in use or during unoccupied period warm-up and setback
operation, unless the system served requires outdoor air or exhaust air or operates continuously or the dampers are opened to provide intentional economizer cooling.

2. Stairway and shaft vent dampers shall be installed with automatic controls configured to open upon the activation of any fire alarm initiating device of the building’s fire alarm system or the interruption of power to the damper.

3.11 SEISMIC REQUIREMENTS

A. See Section 230549 for specific requirements.

B. All HVAC equipment and machinery shall be anchored to withstand forces generated by earthquake motions. As a minimum, equipment and equipment frames shall be designed to withstand a force of 100% of the weight of the equipment and frame acting at its center of gravity. Anchorage of the equipment and/or frame to the structure shall be for a force of four times gravity also acting at the center of gravity.

C. The seismic calculations shall be the responsibility of contractor.

D. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA-Seismic Restraint Manual: Guidelines for Mechanical Systems and ASCE/SEI 7.
   1. Space lateral supports a maximum of 40 feet (12 m) and longitudinal supports a maximum of 80 feet (24 m) on center.
   2. Brace each change of direction longer than 12 feet (3.7 m).

E. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install cable restraints on ducts that are suspended with vibration isolators.

H. Install seismic-restraint devices using methods approved by the AHJ.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

J. Drilling for and Setting Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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. Set anchors to manufacturer’s recommended torque, using a torque wrench.
   5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
3.12 EQUIPMENT
   A. Install equipment as shown on plans and in accordance with manufacturer's installation recommendations.

3.13 SUPPLY DIFFUSER AND REGISTER LOCATIONS
   A. Coordinate location of supply outlets with ceiling mounted smoke detectors. Locate outlets or outlet distribution so as to prevent airflow from inhibiting the operation of smoke detectors. Locate ceiling outlets a minimum of 3'-0" from smoke detectors.

3.14 PAINTING
   A. Where the interior surfaces of ductwork are visible through the blades of supply outlets, return inlets, and exhaust inlets - paint the interior visible surfaces with one coat of flat black paint.
   B. Ductwork exposed on the roof or exterior to the building shall be painted. Coordinate with Division 9 for requirements.

3.15 FIELD QUALITY CONTROL
   A. Do not insulate or conceal ductwork before inspection by Owner's Representative, Architect or Engineer. If ductwork is insulated and concealed prior this inspection the Contractor shall remove insulation and ceiling to permit inspection at no additional cost to the Owner. The Contractor shall replace the insulation and ceiling after final inspection at no additional cost to the Owner.
   B. Ductwork Deflection Criteria:
      1. Maximum inward and/or outward deflection at sheet metal panels shall be 3/4" under maximum static pressure operating conditions. Additional intermediate stiffening angles shall be installed where deflections exceed 3/4".
      2. Maximum inward and/or outward deflection at sheet metal elbows and joints shall be 1/4" under maximum static pressure operating conditions. Additional stiffening angles shall be installed where deflections exceed 1/4".
   C. Acceptance of duct systems shall be contingent upon conformance with the requirements specified in Section 230593 "Testing, Adjusting and Balancing".

3.16 ADJUSTING AND CLEANING
   A. Clean the inside of plenums, casings, enclosures, fans, and accessible ductwork before starting fans. Blowout coils and condensate piping with compressed air. Comb all coil fins that may be bent. Install a clean set of filters in each system prior to testing and balancing. Proceed with testing and balancing. All dampers shall be locked in place.

3.17 DUCT SEALING ALTERNATIVE
   A. Occasionally a ducted system will experience leaks after the ductwork has been installed and sealed per one of the SMACNA duct sealant classifications. These leaks may not be identifiable until after ductwork has been installed and system air balancing and leakage testing has been engaged. At the contractor’s option an alternative solution to sealing such
leaks may include the use of a water based sealing agent that is introduced to the interior of the duct system.

1. Manufacturer: Aeroseal LLC or approved equal. Application must be performed by manufacturer approved provider.
2. Sealant must be UL 723 approved for smoke and flame spread.
3. Sealant must be UL 181 approved for humidity, mold growth, temperature, erosion and puncture resistance.

B. Duct Sealing Procedure:
1. Preparation:
   a. Inspect the entire duct shaft and horizontal plenums for major leakage sites (larger than 1/2” across).
   b. Mechanically clean duct shaft per NADCA (National Air Duct Cleaners Associations) standards if more than 1/8” of surface contaminants are visible on duct surfaces.
   c. Repair all major leakage sites using mastic and fiberglass mesh tape per SMACNA standards.
   d. Temporarily remove or protect all building controls and smoke detectors from aerosol particles as recommended by the Manufacturer.
   e. Temporarily disable fire alarms and notify appropriate authorities.
   f. Temporarily isolate air-moving equipment and block off air inlets and air outlets as recommended by the manufacturer.
   g. Protect occupied spaces from aerosol particles as recommended by the Manufacturer.
   h. Protect air-moving equipment, air inlets and outlets and other devices and appurtenances as recommended by the manufacturers.
2. Duct Sealing:
   a. Seal existing ductwork from the inside using automated aerosolized sealant injection as recommended by manufacturer or by manually caulking internally with sealant.
   b. Sealant must cure within 2 hours with no odor or VOC off-gasing thereafter.
   c. Sealant shall remain elastic (not harden rigidly) after curing.
   d. Sealant shall be deposited substantially at areas of leakage only, and shall not coat interior duct walls, duct lining material, dampers, or turning vanes.
   e. Seal all test holes using patching plates sealed with mastic.
   f. Repair or replace insulation to match existing.
   g. Seal all injection openings with duct access doors or replace ductwork to match existing.
3. Duct Reassembly and Cleanup:
   a. Reinstall building controls and smoke detectors.
   b. Enable fire alarms and notify appropriate authorities.
   c. Remove blocking, reinstall grills and registers, and enable air handling fans.
   d. Cleanup sealant residue that may have adhered to surfaces in occupied areas as recommended by the Manufacturer.
   e. All work shall be done in a substantial and workmanlike manner by factory-trained technicians.
4. Testing:
   a. Provide pre-sealing and post-sealing leakage profile reports indicating percentage reduction of duct leakage for both supply and return ductwork.
   b. Retest ductwork and document compliance with air leakage requirements as identified in section 230593 Testing, Adjusting and Balancing.
5. Warranty:
   a. The Contractor shall warrant that the aerosol sealant application will be free from defects for a period of 3 years from date of the sealing application. If defects should occur during this period, the Contractor shall repair or replace the defective duct
seals, including the direct labor costs for performing the repair or replacement, at no additional cost to the Owner.

END OF SECTION
PART 1 GENERAL

1.1 APPLICABLE REQUIREMENTS

A. All work to be furnished and installed under this section shall comply with all the requirements of General Conditions, Supplemental Conditions, Division 01 - General Requirements, Section 230500 - Basic HVAC Materials and Methods, and other Sections in Division 23 specified herein.

1.2 SCOPE

A. All work to be furnished and installed under this Section shall comply with all the requirements of Division 1, and shall include, but not necessarily be limited to, the following:
   1. Small Cabinet Fans (Ceiling Mounted)
   2. Cabinet Fans (Inline)

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230500: Basic HVAC Materials and Methods
B. Section 230593: Testing, Adjusting and Balancing
C. Section 233113: Air Distribution
D. Division 26: Electrical

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Provide units that are the standard product of an equipment manufacturer regularly engaged in the production of such units who issues complete catalog information on such products. Units shall not be fabricated by the Contractor.

B. Codes and Standards: Provide air handling units conforming to the requirements of the latest addition of the following:
   1. Air Movement and Control Association (AMCA):
      a. 99: Standards Handbook
      b. 210: Laboratory Methods of Testing Fans for Rating
      c. 300: Reverberant Room Method for Sound Testing of Fans
      d. 320: Laboratory Methods of Sound Testing of Fans Using Sound Intensity
      e. 301: Methods for Calculating Fan Sound Ratings from Laboratory Test Data
      a. 9: Load Ratings and Fatigue Life for Ball Bearings
      b. 11: Load Ratings and Fatigue Life for Roller Bearings
   3. National Electrical Manufacturers Association (NEMA): Except for motors, provide electrical components required as part of air handling units, which comply with NEMA Standards.
      a. 70: National Electrical Code
      b. 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
      c. 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Systems
   5. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA): Comply with applicable SMACNA standards including "HVAC Duct Construction Standards - Metal and Flexible."
6. Underwriters Laboratories, Inc. (UL):
   a. UL 507: Standard for Electric Fan
   b. UL 705: Standard for Power Ventilators
   c. UL 1004: Standard for Rotating Electrical Machines-General Requirements

1.5 SAFETY PROVISIONS

   A. Provide all open drives and fan wheels subject to maintenance and potential entanglement with protective guards or screens, with maximum 1/2" openings, meeting OSHA requirements.

1.6 SUBMITTALS

   A. Product Data: Submit manufacturer's technical product data for units showing dimensions, weights, capacities, ratings, fan performance with operating point clearly indicated, motor electrical characteristics, and finishes of materials, installation instructions, sound and vibration test report, and bearing life calculations.

   B. Shop Drawings: Submit shop drawings showing unit dimensions, weight loadings, required clearances, field connection details and methods of support. Draw to a scale of 1/4" per one foot. Include field fabricated mixing boxes, dampers and duct connections.

   C. Maintenance Data: Submit maintenance instructions, including instructions for lubrication, motor and drive replacement, and spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in operating and maintenance manuals.

1.7 ENVIRONMENTAL REQUIREMENTS

   A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.8 DELIVERY, STORAGE, AND HANDLING

   A. Deliver unit to the site in containers with manufacturer’s stamp or label affixed.

   B. Store and protect equipment and products against dirt, water, chemical, and mechanical damage. Do not install damaged unit - remove from project site.

1.9 WARRANTY

   A. Provide minimum one-year warranty from date of Substantial Completion, including all parts, material, labor and travel.

   B. Refer to Section 230500 for additional warranty and Substantial Completion requirements.

PART 2 PRODUCTS

2.1 GENERAL FAN REQUIREMENTS

   A. Construction, Rating and Testing: Provide fans constructed and factory tested in accordance with the Air Moving and Conditioning Association (AMCA). All fan wheels shall be statically and dynamically balanced. Size and capacity as indicated on the Drawings.
B. Motors and Drives: Provide premium efficiency drip-proof motors with temperature rise not greater than 40°C above ambient temperature.
   1. Belt Drive Fans: Provide belt drive assembly capable of 150% of the motor rated horsepower on one less than the total number of belts, for belt drives with two or more belts. All drives shall have adjustable sheaves to allow adjustment of +/-20%. Provide premium efficiency multi-speed motors as indicated on the drawings.
   2. Direct Drive Fans: Provide ECM or premium efficiency motors as indicated on the drawings.

C. Accessories: Provide, as indicated on the drawings and specified in other paragraphs of this Section.

2.2 UTILITY SET

A. Manufacturer: Greenheck, Pen, Twin City, or approved equal.

B. Belt Drive Utility Fans:
   1. Supply, exhaust and return air fans shall be of the belt driven utility fan type in AMCA Arrangement 10 with a single width, single inlet housing, in CW or CCW rotation as specified. The housing shall be constructed of heavy gauge steel with air tightlock formed seams. The housing shall be easily rotated in the field to any of the eight standard discharge positions. Housing and bearing supports shall be constructed of welded steel members to prevent vibration and to rigidly support the shaft and bearings.
   2. Fan wheels shall be of the forward curved type, constructed of heavy gauge steel with uniform stamped steel blades. Wheels shall be statically and dynamically balanced. The wheel cone and fan inlet cone shall be carefully matched for maximum performance and operating efficiency.
   3. Motors shall be heavy duty, ball bearing type, matched to the fan load and furnished at the specified voltage, phase and enclosure. The fan shaft shall be ground and polished solid steel mounted in heavy duty, permanently sealed, pillow block ball bearings. Bearings shall be selected for a minimum L50 life in excess of 200,000 hours of maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulley shall be adjustable for final system balancing.
   4. Provide with VFD ABB ACH series or equal
      a. No bypass
      b. BAS integration, BACnet to JCI
      c. Shaft grounding required

C. All fans shall bear the AMCA Certified Ratings Seal for air performance.

2.3 CABINET INLINE FANS

A. Inline Cabinet Fans (Direct Drive)

B. Duct mounted exhaust shall be of the centrifugal, direct drive type.

C. Housing: The fan housing shall be of the rectangular design constructed of heavy gauge galvanized steel or aluminum and shall include rectangular duct mounting collars. A hinged or removable panel shall be provided in the fan cabinet of sufficient size to permit access for service to all of the fan’s internal components without dismantling the cabinet.
D. The fan wheel shall be of the galvanized steel or aluminum, forward-inclined, centrifugal type. Wheels shall be dynamically and statically balanced. The wheel shaft shall be grounded and polished steel mounted in permanently sealed pillow block bearings.

E. Drives shall be sized for a minimum of 150% of driven horsepower. Bearings shall be selected for a minimum L10 life in excess of 100,000 hours at maximum cataloged operating speed.

F. Motors shall be of the heavy-duty type with permanently sealed ball bearings.
   1. Direct drive: Electronically commutated (EC) motor with potentiometer dial mounted on motor for speed adjustment and 0-10 VDC control wire inputs for connecting to the building automation system for remote control.

G. All fans shall bear the AMCA Certified Ratings Seal for air performance.

H. NEMA-1 disconnect switch to be factory mounted and wired.

I. Manufacturers: Greenheck #CSP-A, Penn, Twin City or equal.

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate motor starters with Division 26 and controls contractor.

B. Install in accordance with manufacturer’s instructions.

C. Examine site to verify if site is ready to receive work. Provide layout drawings of air handlers and fan locations to electrical installer.

D. Install unit on vibration isolators.

E. Install 3” flexible duct connection at inlet and outlet of each unit.

F. Control installers shall install all wiring associated with control signals into the fan starters.

G. Electrical installer shall install all line voltage power wiring and conduit. Coordinate with Division 26 work.

3.2 MANUFACTURER’S START-UP SERVICES

A. The manufacturer shall provide start-up service in the form of a factory trained service technician. The service technician shall verify correct installation, verify unit mounting, verify fan rotation, verify spring isolator adjustments, verify control wiring, verify power wiring, startup the fans, and check for proper operation. The service technician shall provide final adjustments to meet the specified performance requirements. Fully staffed parts and service personnel shall be within four-hours travel time from the job site.

END OF SECTION
PART 1  GENERAL

1.1 WORK INCLUDED

A. Basic electrical requirements for all Division 26 Sections.

1.2 RELATED WORK

A. General requirements specifically applicable to Division 26 in addition to the provisions of Division 1.

1.3 QUALITY ASSURANCE

A. Provide equipment and materials which conform to the standards effective as of the date of the Contract Documents as promulgated by the following bodies:
1. Underwriters' Laboratories (UL).
3. Electrical Testing Laboratories (ETL).
5. Insulated Cable Engineers Association (ICEA).
6. State adopted Electrical Code including local amendments applied to permit documentation.

PART 2  BIDDING

2.1 EXAMINATION OF DOCUMENTS

A. Before submitting a bid, visit the Project Site and become familiar with conditions which may be pertinent to, or affect the cost of, the electrical installation.

B. Become acquainted with the Work of other installers whose activities will adjoin or be affected by the electrical Work. Consult with these other installers and study all pertinent Drawings in order to coordinate the Work and to avoid conflicts, omissions and delays.

C. Before submitting a bid, examine all pertinent Contract Documents for electrical requirements which are not necessarily indicated on the electrical Drawings and include in the bid a sum which is sufficient to cover the costs of these other requirements.

D. Should it be perceived that the Contract Documents do not sufficiently define the required electrical work, contact the Architect for clarification or further description. Failure to do this will be construed as evidence of an understanding of the required electrical systems and their installation.

2.2 PERMITS AND FEES

A. Contractor shall be responsible for obtaining and paying for all necessary electrical permits and fees.

2.3 EXISTING FACILITIES

A. Examine the drawings and specifications of the completed work and inspect the site to establish the scope of demolition work and new work to be provided under this sections and clarification of the phasing of the work.
B. Based on project phasing and scheduling, demolition work will be taking place in and around existing areas that are to remain in service. Where the work under this section affects or interferes with the operation of any existing areas to remain in service, or portions of the work already in operation, provide all necessary work and material including premium pay, required to avoid shutdown of these areas during normal operations. Obtain Owner's approval for shutdown, in writing, 48 hours prior to shut down.

PART 3 EXECUTION

3.1 DRAWINGS

A. For purposes of clarity and legibility, the electrical Drawings are essentially diagrammatic, although the size and location of electrical equipment is drawn to scale wherever possible, make use of all data in all the Contract Documents, and verify this at the Project Site. Determine the exact location of conduits, outlets and equipment by the study of details, shop drawings and/or the Architect's directions.

B. The electrical Drawings show the required size and points of termination of the conduits and the quantity and size of the conductors within. However, the Drawings do not show all the necessary conduit routing. Install conduits in such a manner as to conform to structure, avoid obstruction, preserve headroom and keep passageways and openings clear.

C. Locate outlets symmetrically with architectural elements, notwithstanding the fact that the locations shown of the electrical drawings may be distorted for clarity of representation.

D. The architectural Drawings take precedence over the electrical Drawings. Study the reflected ceiling plans and interior elevations to determine the exact location of lighting fixtures, wall-mounted devices and fixtures, etc. The Architect has taken a very active role in the placement of these items. Should there be a conflict between locations shown on the architectural and electrical drawings, contact the Engineer for clarification prior to rough-in.

3.2 VERIFICATION OF AVAILABLE SPACE

A. Throughout the course of construction, verify that sufficient space will be available for the equipment their required clearances to be installed. If conflict determined, contractor shall contact the design team for clarification on how to proceed.

3.3 EXISTING FACILITIES

A. Based on project phasing and scheduling, demolition work will be taking place in and around existing areas that are to remain in service. Where the work under this section affects or interferes with the operation of any existing areas to remain in service, or portions of the work already in operation, provide all necessary work and material including premium pay, required to avoid shutdown of these areas during normal operations. Obtain Owner's approval for shutdown, in writing, 48 hours prior to shut down.

B. Existing electrical and signal facilities outside of the demolition area to remain in place and in service during demolition.

C. Where areas of existing facilities are indicated to be demolished or remodeled, relocate electric and signal system equipment, and reroute or replace conduit and wiring as required to conform with new use of the area and maintain operation of adjacent areas.
D. Unless specifically noted or otherwise indicated or directed, remove all existing electrical equipment in the areas to be demolished. Deliver all equipment removed, including lighting fixtures, to the Owner's representative.

E. Where remodeling of existing areas is indicated, provide all work indicated and required for a complete and operating facility. Where work is adjacent to existing fixtures or devices, provide matching products to present uniform appearance. Salvage demolished material and equipment and deliver to Owner as directed. Dispose of salvaged materials and equipment where so directed in writing by Owner. Patch all openings in existing walls or floors caused by removal of materials and/or equipment under this work.

3.4 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Protect electrical equipment and materials during transit, storage and handling to prevent damage, soiling and deterioration.

B. Provide new electrical materials and deliver them to the Project Site in unbroken packages.

3.5 WATERPROOFING

A. Wherever electrical Work pierces waterproofing or waterproofing membranes, install it in an approved watertight manner.

3.6 CUTTING AND PATCHING

A. Provide core drilling, cutting and patching of existing construction and surfaces for the installation of electrical systems. Concrete, asphalt or plaster surfaces which have been damaged by such drilling or cutting shall be patched and repaired to match the surrounding surface.

3.7 ADJUST AND CLEAN

A. Keep the Project Site free from accumulations of electrical rubbish and debris. Remove such accumulations from the Project Site.

B. Thoroughly clean electrical equipment and materials of plaster, cement and other foreign materials and leave smooth, clean and dry.

3.8 FIELD QUALITY CONTROL

A. At Project Completion:
   1. Test electrical loads and controls under full operating conditions and immediately replace defective electrical equipment, devices and workmanship at no cost to the Owner.
   2. Perform all standard electrical functional tests, such as electrical insulation and ground resistance, or temperature rise, as well as the tests required in subsequent sections.

B. Closing-in of Work: Do not allow Electrical Work to be covered or enclosed until it has been observed by the Architect's Representative. Should unobserved Electrical Work be covered or enclosed, uncover it for observation and then make repairs as necessary to restore the Electrical Work and the Work of other affected installers to its original and proper condition, at no cost to the Owner.
3.9 CONSTRUCTION ADMINISTRATION

A. Substitutions
   1. Refer to other Sections of these Specifications for substitution requirements.

B. Submittals
   1. All submittals shall be provided in electronic format for review.
   2. All submittals associated within a single specification section shall be submitted as a single package. Piecemeal submittals will be rejected as incomplete.
   3. Re-submittals shall only include the requested resubmittal documentation. A complete resubmittal including approved equipment and materials will be rejected.
   4. If an error in the submittals is not detected during the review process, this does not grant the contractor permission to proceed in error. Regardless of any information contained in the submittals, the requirements of the drawings and specifications must be followed and are not waived or superseded by the submittal review. Any conflicting information shall be brought to the attention of the engineer and design team through the RFI process.

C. Requests for Information (RFIs)
   1. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified (refer to Division 1).
      a. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
      b. RFIs shall address single questions and related issues only.
      c. All RFIs shall be thoroughly reviewed and approved by the General Contractor and/or Construction Manager for accuracy and need for information required before submittal to Owner's Design Representative.
   2. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
      a. Project name.
      b. Project number.
      c. Date.
      d. Name of Contractor.
      e. Name of Architect [and Construction Manager].
      f. RFI number, numbered sequentially and unique.
      g. RFI subject.
      h. Specification Section number and title and related paragraphs, as appropriate.
      i. Drawing number and detail references, as appropriate.
      j. Field dimensions and conditions, as appropriate.
      k. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
      l. Contractor's signature.
      m. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
      n. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.
   3. RFI format to be the following:
      a. RFI issue statement.
      b. RFI question to the engineer.
      c. Contractor recommendation.
   4. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow a minimum three business days for Engineer's response for each RFI, plus
additional time for Architect and General Contractor to review and forward. RFIs received by Engineer after 1:00 p.m. will be considered as received the following working day.

a. The following Contractor-generated RFIs will be returned without action:
   1) Incomplete RFIs or inaccurately prepared RFIs.
   2) RFIs submitted without indication of review and approval for submission by General Contractor
   3) RFIs addressing multiple unrelated issues.
   4) Requests for approval of submittals.
   5) Requests for approval of substitutions.
   6) Requests for approval of Contractor's means and methods.
   7) Requests for information already indicated in the Contract Documents.
   8) Requests for adjustments in the Contract Time or the Contract Sum.
   9) Requests for interpretation of Engineer's actions on submittals.
   10) Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt of additional information.

D. Installation Drawings
   1. Prepare dimensionally accurate floor plans of each electrical and signal room and/or closet, fire control room and the like, drawn to 1/4" scale minimum. Submit electronic copies for review with two prints for Architect's record. Indicate all equipment within the rooms to scale based on shop drawing data, include structural support for suspended equipment and description of seismic bracing and fastening. Indicate system and equipment grounding details as applicable. Review elevator machine room shop drawings and coordinate location of electrical gear to maintain clearances. Submit with shop drawings.
   2. Where conduit runs, 2" trade size and larger, are run in exposed locations, prepare dimensionally accurate floor plans indicating routing, coordinated with work of other trades and the structure. Submit legible reproducible transparencies with two prints for review.

E. Project Record Documents
   1. Maintain Record Documents which clearly indicate variances from the specified systems, and which accurately locate all underground electrical conduits and structures.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Copper building wire.
   2. Nonmetallic underground conduit with conductors, Type NUCC.
   3. Metal-clad cable, Type MC.
   4. Fire-alarm wire and cable.
   5. Connectors and splices.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

C. Field quality-control reports.

PART 2 PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with
   an overall insulation layer or jacket, or both, rated 600 V or less.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the
   following:
   a. Alpha Wire Company.
   b. American Bare Conductor.
   c. Belden Inc.
   d. Cerro Wire LLC.
   e. Encore Wire Corporation.
   f. General Cable; Prysmian Group North America.
   g. Okonite Company (The).
   h. Service Wire Co.
   i. Southwire Company, LLC.
   j. WESCO.

B. Standards:

   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for
      intended location and use.
   2. Conductor and Cable Marking: Comply with wire and cable marking according to UL’s
      "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8
   for stranded conductors.

D. Conductor Insulation:

   1. Type NM: Comply with UL 83 and UL 719.
   2. Type RHH and Type RHW-2: Comply with UL 44.
   3. Type USE-2 and Type SE: Comply with UL 854.
   4. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
   5. Type THHN and Type THWN-2: Comply with UL 83.
6. Type THW and [Type THW-2]: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
7. Type UF: Comply with UL 83 and UL 493.
8. Type XHHW-2: Comply with UL 44.

2.2 NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS, TYPE NUCC

A. Description: A factory assembly of conductors or cables inside a nonmetallic, smooth wall raceway with a circular cross section.

B. Applicable Standards:
   1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
   2. General Characteristics:

2.3 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AFC Cable Systems; Atkore International.
      b. Alpha Wire Company.
      c. American Bare Conductor.
      d. Belden Inc.
      e. Encore Wire Corporation.
      f. General Cable; Prysmian Group North America.
      g. Okonite Company (The).
      h. Service Wire Co.
      i. Southwire Company, LLC.
      j. WESCO.

B. Standards:
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   2. Comply with UL 1569.
   3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

E. Ground Conductor: Bare.

F. Conductor Insulation:
   1. Type TFN/THHN/THWN-2: Comply with UL 83.
   2. Type XHHW-2: Comply with UL 44.

G. Armor: Steel, interlocked.
2.4 FIRE-ALARM WIRE AND CABLE
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Wire & Cable Inc.
   b. CommScope, Inc.
   c. Comtran Corporation.
   d. Genesis Cable Products; Honeywell International, Inc.
   e. Prysmian Cables and Systems; Prysmian Group North America.
   f. PYROTECH; brand of nVent Electrical plc.
   g. Radix Wire.
   h. Rockbestos-Suprenant Cable Corp.
   i. Superior Essex Inc.; subsidiary of LS Corp.
   j. West Penn Wire.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 16 AWG.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
   1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
   2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. 3M Electrical Products.
      b. ABB, Electrification Business.
      c. AFC Cable Systems; Atkore International.
      d. Gardner Bender.
      e. Hubbell Utility Solutions; Hubbell Incorporated.
      f. Ideal Industries, Inc.
      g. ILSCO.
      h. NSI Industries LLC.
      j. Service Wire Co.
      k. TE Connectivity Ltd.

B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper.
   2. Type: Two hole with standard barrels.
   3. Termination: Compression.
3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Branch Circuits:
   1. Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

B. ASD Output Circuits Cable: Extra-flexible stranded for all sizes.


3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.

B. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway. Metal-clad cable, Type MC.

C. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway. Type XHHW-2, single conductors in raceway.

D. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION, GENERAL

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points 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."

G. Complete cable tray systems installation according to Section 260536 "Cable Trays for Electrical Systems" prior to installing conductors and cables.

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with NFPA 72.

B. Wiring Method: Install wiring in metal pathway.
1. Install plenum cable in environmental airspaces, including plenum ceilings.

2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
   a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and Cl, is not permitted.

4. Signaling Line Circuits: Power-limited fire-alarm cables must not be installed in the same cable or pathway as signaling line circuits.

C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes; cabinets; or equipment enclosures where circuit connections are made.

E. Color-Coding: Match existing infrastructure.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch (150 mm) of slack.

3.6 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.

3.7 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. Tests and Inspections:
   1. 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.
   3) Thermographic survey.

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 for ground and adjacent conductors.
   Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.

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
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Support, anchorage, and attachment components.
   2. Fabricated metal equipment support assemblies.

1.2 SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components
      and profiles, and finishes for the following:
      a. Slotted support systems, hardware, and accessories.
      b. Clamps.
      c. Hangers.
      d. Sockets.
      e. Eye nuts.
      f. Fasteners.
      g. Anchors.
      h. Saddles.
      i. Brackets.
   2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and
   installation details for electrical hangers and support systems.
   2. Slotted support systems.
   3. Equipment supports.

C. Delegated Design Submittal: For hangers and supports for electrical systems.
   1. Include design calculations and details of hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified structural professional engineer to design hanger and
   support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum
   13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one
   surface.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
      a. ABB, Electrification Business.
      b. Allied Tube & Conduit; Atkore International.
c. **CADDY**, brand of nVent Electrical plc.
d. **Cooper B-line**, brand of Eaton, Electrical Sector.
e. **Flex-Strut Inc.**
f. **Gripple Inc.**
g. **G-Strut.**
h. **Haydon Corporation.**
i. **Metal Ties Innovation.**
j. **MIRO Industries.**
k. **Rocket Rack**, Robroy Industries.

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.

1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   a. **ABB, Electrification Business.**
   b. **Cooper Industries, Inc.**
   c. **Flex-Strut Inc.**
   d. **Haydon Corporation.**
   e. **MKT Metal Manufacturing.**
   f. **Unistrut, Atkore International.**

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
5. Channel Width: Selected for applicable load criteria.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.

1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   a. **Allied Tube & Conduit, Atkore International.**
   b. **Champion Fiberglass, Inc.**
   c. **Cooper B-line**, brand of Eaton, Electrical Sector.
   d. **Fabco Plastics Wholesale Limited.**
   e. **G-Strut.**
   f. **Haydon Corporation.**
g. Seasafe, Inc.; AMICO, a Gibraltar Industries Company.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Channel Width: Selected for applicable load criteria.
4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
6. Rated Strength: Selected to suit applicable load criteria.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non armored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

F. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

G. 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:
      (a) Hilti, Inc.
      (b) ITW Ramset/Red Head; Illinois Tool Works, Inc.
      (c) MKT Fastening, LLC.
      (d) 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:
         (a) Cooper B-line; brand of Eaton, Electrical Sector.
         (b) Empire Tool and Manufacturing Co., Inc.
         (c) Hilti, Inc.
         (d) ITW Ramset/Red Head; Illinois Tool Works, Inc.
         (e) 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 F3125/F3125M, Grade A325 (Grade A325M).
   6. Toggle Bolts: All steel springhead type.
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 SELECTION

A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
   1. NECA NEIS 101
   2. NECA NEIS 102.
   3. NECA NEIS 105.
   4. NECA NEIS 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch (6 mm) in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch (38 mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT, IMC and ERMC may be supported by openings through structure members, in accordance with 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 must be weight of supported components plus 200 lb (90 kg).
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. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
6. To Light Steel: Sheet metal screws.
7. 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. Submit welding certificates.

3.4 PAINTING
A. Touchup:
1. 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.
   a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION
PART 1  GENERAL

1.1  SUMMARY

A. Section Includes:
   1. Metal conduits and fittings.
   2. Nonmetallic conduits and fittings.
   3. Metal wireways and auxiliary gutters.
   4. Nonmetal wireways and auxiliary gutters.
   5. Surface raceways.

B. Related Requirements:
   1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.2  DEFINITIONS

A. ARC: Aluminum rigid conduit.
B. EMT: Electric Metallic Tube.
C. ENT: Electrical Nonmetallic Tube.
D. FMC: Flexible Metal Conduit.
E. GRC: Galvanized rigid steel conduit.
F. HDPE: High Density Polyethylene.
G. IMC: Intermediate metal conduit.
H. LFMC: Liquid-tight Flexible Metal Conduit.
I. LFNC: Liquid-tight Flexible Nonmetallic Conduit.
J. RNC: Rigid Nonmetallic Conduit.
K. RTRC: Reinforced Thermosetting Resin Conduit (Fiberglass).

1.3  SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Seismic Qualification Data: 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. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
PART 2 PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. GRC: Comply with ANSI C80.1 and UL 6.
3. IMC: Comply with ANSI C80.6 and UL 1242.
4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit or IMC.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch (1 mm), minimum.
5. EMT: Comply with ANSI C80.3 and UL 797.
6. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:
1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. 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.
5. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: 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 AND FITTINGS

A. Nonmetallic Conduit:
1. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. fiberglass:
   b. Comply with UL 2515 for aboveground raceways.
   c. Comply with UL 2420 for belowground raceways.
3. RNC: Type EPC-40-PVC or Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
4. LFNC: Comply with UL 1660.
5. Rigid HDPE: Comply with UL 651A.

B. Nonmetallic Fittings:
1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
   a. Fittings for LFNC: Comply with UL 514B.
3. Solvents and Adhesives: As recommended by conduit manufacturer.
2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal, complying with UL 870 and NEMA 250, 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.

B. 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.

C. Wireway Covers: Hinged type or Screw-cover type unless otherwise indicated.

D. 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.

C. Tele-Power Poles:
   1. Material: Galvanized steel or Aluminum with finish and color selected by the architect.
   2. Fittings and Accessories: Dividers, end caps, covers, cutouts, wiring harnesses, devices, mounting materials, and other fittings shall match and mate with tele-power pole as required for complete system.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

D. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover.

G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) unless otherwise indicated.
I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250 with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.

PART 3 EXECUTION

3.1 RACEWAY APPLICATION

A. Indoors: Apply raceway products as specified below unless otherwise indicated:
   1. Exposed, Not Subject to Physical Damage: EMT.
   2. Exposed and Subject to Physical Damage: GRC.
   3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
   4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
   5. Damp or Wet Locations: IMC.
   6. 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.

B. Minimum Raceway Size: 1/2-inch trade size.

C. 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 or cast-metal 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.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. 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.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.
G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of four 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. 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.

M. 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.

N. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

O. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

P. 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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

R. 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.

S. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

U. 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.

V. 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. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

W. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) 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 top 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 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
3.4 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
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Labels.
   2. Bands and tubes.
   3. Tapes and stencils.
   4. Tags.
   5. Signs.
   6. Cable ties.
   7. Miscellaneous identification products.

1.2 SUBMITTALS

A. None.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with 29 CFR 1910.144 for color identification of hazards; 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs and tags; and the following:
   1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.

C. Signs, labels, and tags required for personnel safety must comply with the following standards:
   5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

D. Comply with NFPA 70E requirements for arc-flash warning labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, must comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 1000 V or Less:
   1. Black letters on orange field.
   2. Legend: Indicate voltage.
B. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded branch-circuit conductors.
   1. Color must be factory applied.
   2. Colors for 208Y/120 V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
      c. Phase C: Blue.
   3. Colors for 240 V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
   4. Colors for 480Y/277 V Circuits:
      b. Phase B: Orange.
      c. Phase C: Yellow.
   6. Color for Equipment Grounds: Bare copper.

C. Warning Label Colors:
   1. Identify system voltage with black letters on orange background.

D. Warning labels and signs must include, but are not limited to, the following legends:
   1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

E. Equipment Identification Labels:
   1. Black letters on white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Preprinted, 3 mil (0.08 mm) thick, polyester flexible label with acrylic pressure-sensitive adhesive.
   1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over legend. Labels sized such that clear shield overlaps entire printed legend.
   2. Marker for Labels:
      a. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3 mil (0.08 mm) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
   1. Minimum Nominal Size:
      a. 1-1/2 by 6 inch (37 by 150 mm) for raceway and conductors.
      b. 3-1/2 by 5 inch (76 by 127 mm) for equipment.
      c. As required by authorities having jurisdiction.
2.4 BANDS AND TUBES

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.


2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil (0.08 mm) thick by 1 to 2 inch (25 to 50 mm) wide; compounded for outdoor use.

C. Tape and Stencil: 4 inch (100 mm) wide black stripes on 10 inch (250 mm) centers placed diagonally over orange background and are 12 inch (300 mm) wide. Stop stripes at legends.

D. Floor Marking Tape: 2 inch (50 mm) wide, 5 mil (0.125 mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.6 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) thick, color-coded for phase and voltage level, with factory [screened] [printed] permanent designations; punched for use with self-locking cable tie fastener.

C. Write-on Tags:
   1. Polyester Tags: 0.010 inch (0.25 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
   2. Marker for Tags:
      a. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
   1. Minimum Width: 3/16 inch (5 mm).
   2. Tensile Strength at 73 deg F (23 deg C) in accordance with ASTM D638: 12,000 psi (82.7 MPa).
   3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
2.8 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 item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side. 1. Secure tight to surface of conductor, cable, or raceway.


I. Emergency Operating Instruction Signs: Install instruction signs with white legend on red background with minimum 3/8 inch (10 mm) high letters for emergency instructions at equipment used for power transfer.

J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

K. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows: 1. "EMERGENCY POWER." 2. "POWER."
3. "UPS."

L. Vinyl Wraparound Labels:
1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

O. Self-Adhesive Labels:
1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high label; where two lines of text are required, use labels 2 inch (50 mm) high.

P. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

Q. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.

R. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

S. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

T. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

V. Metal Tags:
1. Place in location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

W. Nonmetallic Preprinted Tags:
1. Place in location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

X. Write-on Tags:
1. Place in location with high visibility and accessibility.
2. Secure using general-purpose cable ties.

Y. Baked-Enamel Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on minimum 1-1/2 inch (38 mm) high sign; where two lines of text are required, use signs minimum 2 inch (50 mm) high.

Z. Metal-Backed Butyrate Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high sign; where two lines of text are required, use labels 2 inch (50 mm) high.

AA. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
2. Unless otherwise indicated, provide single line of text with 1/2 inch (13 mm) high letters on 1-1/2 inch (38 mm) high sign; where two lines of text are required, use labels 2 inch (50 mm) high.

BB. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft (15 m) maximum intervals in straight runs, and at 25 ft (7.6 m) maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify cover of junction and pull box of the following systems with self-adhesive labels containing wiring system legend and system voltage. System legends must be as follows:
1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags with conductor or cable designation, origin, and destination.

F. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with conductor designation.

G. Conductors to Be Extended in Future: Attach write-on tags marker tape to conductors and list source.
H. Auxiliary Electrical Systems Conductor Identification: Marker tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
   1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

I. Workspace Indication: Apply floor marking tape or tape and stencil to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

J. Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.
   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
      a. Power-transfer switches.
      b. Controls with external control power connections.
      c. Enclosures and electrical cabinets.
      d. Access doors and panels for concealed electrical items.
      e. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
      f. Emergency system boxes and enclosures.
      g. Motor-control centers.
      h. Enclosed switches.
      i. Enclosed circuit breakers.
      j. Enclosed controllers.
      k. Variable-speed controllers.
      l. Push-button stations.
      m. Power-transfer equipment.
      n. Contactors.
      o. Remote-controlled switches, dimmer modules, and control devices.
      p. Battery-inverter units.
      q. Battery racks.
      r. Power-generating units.
      s. Monitoring and control equipment.

END OF SECTION
PART 1 GENERAL

1.1 SUMMARY
A. Section Includes:
   1. Daylight-harvesting switching controls.
   2. Daylight-harvesting dimming controls, analog.
   3. Daylight-harvesting dimming controls, digital.
   4. Indoor occupancy and vacancy sensors.
   5. Emergency shunt relay.
   6. Conductors and cables.

1.2 SUBMITTALS
A. Product Data:
   1. For each type of product.

B. Shop Drawings:
   1. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
   2. Interconnection diagrams showing field-installed wiring.
   3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

D. Sample Warranty: For manufacturer's warranties.

1.3 WARRANTY
A. Special Extended Warranty: Manufacturer and Installer warrant that installed lighting control devices perform in accordance with specified requirements and agree to repair or replace, including labor, materials, and equipment, devices that fail to perform as specified within extended warranty period.
   1. Failures include, but are not limited to, the following:
      a. Faulty operation of lighting control software.
      b. Faulty operation of lighting control devices.

PART 2 PRODUCTS

2.1 DAYLIGHT-HARVESTING SWITCHING CONTROLS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Industries, Inc.
   2. Eaton.
   3. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   4. Leviton Manufacturing Co., Inc.
   5. Lithonia Lighting; Acuity Brands Lighting, Inc.
   6. NSi Industries LLC.
   7. Sensor Switch, Inc.
   8. TE Connectivity Ltd.
   9. WattStopper; Legrand North America, LLC.
B. Description: System operates indoor lighting.

C. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.
   1. Lighting control set point is based on two lighting conditions:
      a. When no daylight is present.
      b. When significant daylight is present (target level).
      c. System programming is done with two hand-held, remote-control tools.

D. Ceiling-Mounted Switching Controls:
   1. Solid-state, light-level sensor unit, with integrated power pack, that detects changes in indoor lighting levels that are perceived by the eye.

E. Electrical Components, Devices, and Accessories:
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
   3. Sensor Output:
      a. Contacts rated to operate the associated power pack, complying with UL 773A.
         Sensor must be powered by the power pack.
      b. Digital signal compatible with power pack.
   4. Sensor type: Closed loop.
   6. Power Pack:
      a. Dry contacts rated for 20 A LED load at 120- and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
         1) LED status lights to indicate load status.
         2) Plenum rated.
   7. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn-on and turn-off levels within that range.
   8. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
   9. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
   10. Test Mode: User selectable, overriding programmed time delay to allow settings check.
   11. Control Load Status: User selectable to confirm that load wiring is correct.
   12. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.2 DAYLIGHT-HARVESTING DIMMING CONTROLS, ANALOG

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   3. Leviton Manufacturing Co., Inc.
   4. Lithonia Lighting; Acuity Brands Lighting, Inc.
   5. WattStopper; Legrand North America, LLC.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
   1. Lighting control set point is based on two lighting conditions:
      a. When no daylight is present (target level).
      b. When significant daylight is present.
2. System programming is done with two hand-held, remote-control tools.
   a. Initial setup tool.
   b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Sensor Output: zero to 10 V(dc) to operate luminaires. Sensor is powered by controller unit.
   3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lx).

E. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source
   1. LED status lights to indicate load status.
   2. Plenum rated.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper Industries, Inc.
   2. Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   3. Leviton Manufacturing Co., Inc.
   4. Lithonia Lighting; Acuity Brands Lighting, Inc.
   5. WattStopper; Legrand North America, LLC.

B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.
   1. Lighting control set point is based on the following two lighting conditions:
      a. When no daylight is present (target level).
      b. When significant daylight is present.
   2. System programming is done with two hand-held, remote-control tools.
      a. Initial setup tool.
      b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated power pack, to detect changes in indoor lighting levels that are perceived by the eye.

D. Electrical Components, Devices, and Accessories:
   1. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   2. Sensor Output: zero to 10 V(dc) to operate luminaires. Sensor is powered by controller unit.
   3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lx).
E. **Power Pack:** Digital controller capable of accepting three 8PSJ inputs with one output(s) rated for 20 A incandescent or LED load at 120 and 277 V(ac), for 13 A LED at 120 and 277 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc) Class 2 power source.
   1. With integral current monitoring.
   2. Compatible with digital addressable lighting interface.
   3. Plenum rated.

2.4 **INDOOR OCCUPANCY AND VACANCY SENSORS**

A. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   1. **Bryant; brand of Hubbell Electrical Solutions; Hubbell Incorporated.**
   2. **Cooper Industries, Inc.**
   3. **Hubbell Control Solutions; brand of Hubbell Electrical Solutions; Hubbell Incorporated.**
   4. **Leviton Manufacturing Co., Inc.**
   5. **Lithonia Lighting; Acuity Brands Lighting, Inc.**
   6. **Lutron Electronics Co., Inc.**
   7. **NSi Industries LLC.**
   8. **Sensor Switch, Inc.**

B. **General Requirements for Sensors:**
   2. Dual technology.
   3. Integrated power pack.
   4. Hardwired connection to switch and BAS.
   5. Operation:
      a. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.
   7. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.
   8. Mounting:
      a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
      b. Relay: Externally mounted through a 1/2 inch (13 mm) knockout in a standard electrical enclosure.
      c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   9. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
   10. Bypass Switch: Override the "on" function in case of sensor failure.
   11. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); turn lights off when selected lighting level is present.

C. **Dual-Technology Type:** Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
   1. **Sensitivity Adjustment:** Separate for each sensing technology.
   2. **Detector Sensitivity:** Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm), and detect a person of average size and weight moving not less than 12 inch (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inch/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.

4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft. (110 sq. m) when mounted 48 inch (1200 mm) above finished floor.

2.5 EMERGENCY SHUNT RELAY

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Lighting Control and Design.
   2. WattStopper; Legrand North America, LLC.

B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

2.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SENSORS

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

3.3 INSTALLATION OF WIRING

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).
B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's instructions.

C. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems.
   1. Identify controlled circuits in lighting contactors.
   2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Field tests must be witnessed by Owner.

B. Tests and Inspections:
   1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Nonconforming Work:
   1. Lighting control devices will be considered defective if they do not pass tests and inspections.
   2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:
   1. Engage factory-authorized service representative to support field tests and inspections.

END OF SECTION
PART 1  GENERAL

1.1  SUMMARY

A. Section Includes:
   1. General-use switches, dimmer switches, and fan-speed controller switches.
   2. General-grade duplex straight-blade receptacles.
   3. Receptacles with ground-fault protective devices.

1.2  DEFINITIONS

A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.

B. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

1.3  SUBMITTALS

A. Product Data:
   1. Toggle switches.
   2. Momentary-contact switches.
   3. Rocker switches.
   4. Dimmer switches.
   5. Duplex straight-blade receptacles.
   6. Receptacles with GFCI device.

B. Field Quality-Control Submittals:
   1. Field quality-control reports.

C. Manufacturers' Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:
   1. Dimmers.
   2. Duplex straight-blade receptacles.
   3. Receptacles with GFCI device.

D. Sample warranties.

PART 2  PRODUCTS

2.1  GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

A. Toggle Switch:
   1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing
      laboratory recognized by authorities having jurisdiction, and marked for intended
      location and application.

3. General Characteristics:

4. Options:
   a. Device Color: White, as indicated on architectural drawings.
   b. Configuration:

5. Accessories:
   a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with
      smooth finish and color matching wiring device; from same manufacturer as wiring
      device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Rocker Switch:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell
         Incorporated.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour; Legrand North America, LLC.
   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing
         laboratory recognized by authorities having jurisdiction, and marked for intended
         location and application.
   3. General Characteristics:
   4. Options:
      a. Device Color: White, as indicated on architectural drawings.
      b. Configuration:
         1) 120-277 V, 20 A, single pole.
   5. Accessories:
      a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with
         smooth finish and color matching wiring device; from same manufacturer as wiring
         device.
      b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Type I Dimmer Switch:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the
      following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. GE Lighting; General Electric Company.
      c. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell
         Incorporated.
      d. Leviton Manufacturing Co., Inc.
      e. Lutron Electronics Co., Inc.
      f. Pass & Seymour; Legrand North America, LLC.
   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing
         laboratory recognized by authorities having jurisdiction, and marked for intended
         location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN EOYX and UL 1472 Type I dimmer.

4. Options:
   a. Device Color: White, as indicated on architectural drawings.
   b. Switch Style: Rocker.
   c. Dimming Control Style: Slide.

5. Accessories:
   a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.2 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour; Legrand North America, LLC.

   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

   3. General Characteristics:

   4. Options:
      a. Device Color: White, as indicated on architectural drawings.
      b. Configuration:
         1) General-duty, NEMA 5-20R.

   5. Accessories:
      a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
      b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
      b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
      c. Leviton Manufacturing Co., Inc.
      d. Pass & Seymour; Legrand North America, LLC.

   2. Regulatory Requirements:
      a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

   3. General Characteristics:

   4. Options:
      a. Device Color: White, as indicated on architectural drawings.
b. Configuration:
   1) General-duty, NEMA 5-20R.

5. Accessories:
   a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

C. Tamper-Resistant Duplex Straight-Blade Receptacle with USB Outlet to Power Class 2 Equipment:
1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
4. Options:
   a. Device Color: White, as indicated on architectural drawings.
   b. Configuration:
      1) General-duty, NEMA 5-20R; two USB-A ports.
5. Accessories:
   a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

D. Wired Half-Controlled Duplex Straight-Blade Receptacle:
1. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Lighting; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
   c. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
   a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
   a. Reference Standards: UL CCN RTXI and UL Subject 498B.
4. Options:
   a. Device Color: White, as indicated on architectural drawings.
   b. Configuration: NEMA 5-20R.
5. Accessories:
   a. Cover Plate: **0.060 inch (1.5 mm)** thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
PART 3  EXECUTION

3.1  EXAMINATION

A.  Receptacles:
   1.  Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2  INSTALLATION OF SWITCHES

A.  Comply with manufacturer's instructions.

B.  Reference Standards:
   1.  Unless more stringent requirements are specified in Contract Documents or manufacturers’ instructions, comply with installation instructions in NECA NEIS 130.
   3.  Consult Architect for resolution of conflicting requirements.

C.  Identification:
   1.  Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

3.3  INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A.  Comply with manufacturer's instructions.

B.  Reference Standards:
   1.  Unless more stringent requirements are specified in Contract Documents or manufacturers’ instructions, comply with installation instructions in NECA NEIS 130.
   4.  Consult Architect for resolution of conflicting requirements.

C.  Identification:
   1.  Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

3.4  FIELD QUALITY CONTROL OF SWITCHES

A.  Field tests and inspections must be witnessed by Owner.

B.  Tests and Inspections:
   1.  Perform tests and inspections in accordance with manufacturers’ instructions.

C.  Nonconforming Work:
   1.  Unit will be considered defective if it does not pass tests and inspections.
   2.  Remove and replace defective units and retest.

D.  Assemble and submit test and inspection reports.
   1.  inspections.
3.5 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Field tests and inspections must be witnessed by Owner.

B. Tests and Inspections:
   1. Insert and remove test plug to verify that device is securely mounted.
   2. Verify polarity of hot and neutral pins.
   3. Measure line voltage.
   4. Measure percent voltage drop.
   5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.

C. Nonconforming Work:
   1. Device will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective units and retest.

D. Assemble and submit test and inspection reports.

3.6 PROTECTION

A. Devices:
   1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
   2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION
PART 1  GENERAL

1.1 RELATED DOCUMENTS

1.2 SUMMARY

A. Section Includes:
   1. Cartridge fuses rated 600 V ac and less for use in the following:
      a. Control circuits.
      b. Motor-control centers.
      c. Enclosed controllers.
      d. Enclosed switches.

1.3 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:

PART 2  PRODUCTS

2.1 MANUFACTURERS

A. **Manufacturers**: Subject to compliance with requirements, provide products by one of the following:
   1. **Bussmann; Eaton, Electrical Sector**.
   2. **Littelfuse, Inc**.
   3. **Mersen USA**.

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.
   4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC.
   5. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
   6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC.

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.
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. Motor Branch Circuits: Class RK, Class RK5, time delay.
   2. Large Motor Branch (601-4000 A): Class L, time delay.
   4. Other Branch Circuits: Class RK1, time delay Class RK5, time delay.
   5. Control Transformer Circuits: Class CC, time delay, control transformer duty.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

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
PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Fusible switches.
   2. Nonfusible switches.
   3. Receptacle switches.
   4. Shunt trip switches.
   5. Molded-case circuit breakers (MCCBs).
   7. Enclosures.

1.2 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
   1. Enclosure types and details for types other than NEMA 250, Type 1.
   2. Current and voltage ratings.
   3. Short-circuit current ratings (interrupting and withstand, as appropriate).

B. Shop Drawings: For enclosed switches and circuit breakers.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

C. Qualification Data: For qualified testing agency.

D. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, 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.

E. Field quality-control reports.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data,"
1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.
   1. Testing Agency’s Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.5 WARRANTY

A. Manufacturer’s Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers 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.

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   4. Square D; Schneider Electric USA.

B. Type HD, Heavy Duty:
   1. Single throw.
   2. Three pole.
   3. 600-V ac.
   4. 200 A and smaller.
   5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
   6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Lugs: Mechanical type, suitable for number, size, and conductor material.
4. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   4. Square D; Schneider Electric USA.

B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Accessories:
   1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   3. Lugs: Mechanical type, suitable for number, size, and conductor material.
   4. Service-Rated Switches: Labeled for use as service equipment.

2.5 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. NOARK Electric North America.
   5. Square D; Schneider Electric USA.

B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated. combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement...
"Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

E. MCCBs shall be equipped with a device for locking in the isolated position.

F. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below.

G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.


I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   1. Instantaneous trip.
   2. Long- and short-time pickup levels.
   3. Long- and short-time time adjustments.
   4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

O. Features and Accessories:
   1. Standard frame sizes, trip ratings, and number of poles.
   2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.

2.6 MOLDED-CASE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB, Electrification Business.
   2. Eaton.
   3. NOARK Electric North America.
   5. Square D; Schneider Electric USA.

B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.

D. Features and Accessories:
   1. Standard frame sizes and number of poles.
   2. Lugs:
      a. Mechanical type, suitable for number, size, trip ratings, and conductor material.
      b. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below.
   3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.

2.7 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1).

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover directly operable through the front cover of the enclosure (NEMA 250 Type 1). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.
   1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.
3.2 PREPARATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R.
3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.4 INSTALLATION

A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
D. Install fuses in fusible devices.
E. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections with the assistance of a factory-authorized service representative.
C. Tests and Inspections for Switches:
   1. Visual and Mechanical Inspection:
      a. Inspect physical and mechanical condition.
      b. Inspect anchorage, alignment, grounding, and clearances.
      c. Verify that the unit is clean.
      d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
      e. Verify that fuse sizes and types match the Specifications and Drawings.
      f. Verify that each fuse has adequate mechanical support and contact integrity.
      g. Inspect bolted electrical connections for high resistance using one of the two following methods:
         1) Use a low-resistance ohmmeter.
            (a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
         2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
            (a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
      h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
      i. Verify correct phase barrier installation.
      j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
   2. Electrical Tests:
      a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
      c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
      d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
      e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded Case Circuit Breakers:
   1. Visual and Mechanical Inspection:
      a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
      b. Inspect physical and mechanical condition.
      c. Inspect anchorage, alignment, grounding, and clearances.
      d. Verify that the unit is clean.
      e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:
   1) Use a low-resistance ohmmeter.
      (a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
   2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
      (a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

2. Electrical Tests:
   a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
   c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
   d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
   e. Determine the following by primary current injection:
      1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
      4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
   f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
   g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
   h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.
   1. Test procedures used.
   2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
   3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION