Compton Community College District

CCC-029

Boiler Replacement Project

Specifications

(177 pages)

SECTION 05 12 00

STRUCTURAL STEEL

1. GENERAL

1.01 SECTION INCLUDES

A. Structural steel framing members.
   1. Galvanized at exterior exposed structural steel.

B. Related Sections
   1. Section 05 05 14, Hot-Dip Galvanizing

1.02 REFERENCES

A. AISC - American Institute of Steel Construction
   1. AISC Manual – AISC Manual of Steel Construction, 13th Edition
   2. AISC S323 - Quality Criteria and Inspection Standards

B. ASTM - American Society for Testing and Materials
   1. ASTM A36 - Structural Steel
   2. ASTM A123 - Zinc (Hot Dipped Galvanized) Coatings on Iron and Steel Products
   3. ASTM A307 - Carbon Steel Externally Threaded Standard Fasteners
   4. ASTM A500 - Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Round and Shapes
   5. ASTM A572 - Grade 50 - Structural Steel

C. ASCE/SEI 7-05 – American Society of Civil Engineers, Structural Engineers Institute, ASCE Standard.

D. AWS - American Welding Society
   1. AWS A2.4 - Standard Symbols for Welding, Brazing and Non Destructive Examination
   2. AWS A5.1 – Carbon Steel Electrodes for Shielded Metal Arc-Welding
   3. AWS B2.1 – Welding Procedure and Performance Qualification
   4. AWS D1.1 – Structural Welding Code, Steel
   5. AWS D1.3 – Structural Welding Code, Sheet Steel
   6. AWS D1.8 – Structural Welding Code, Seismic Supplement

E. SSPC - Steel Structures Painting Council.

F. CBC - California Building Code 2010**,** Chapter 22.

G. ASTM A992 - Steel for Structural Shapes For Use in Building Framing

1.03 SUBMITTALS

A. Shop Drawings:
   1. Indicate profiles, sizes, spacing and locations of structural members, connections, openings, attachments and fasteners.
   2. Indicate cambers.
   3. Indicate welded connections with AWS A2.4 welding symbols. Indicate net weld lengths.

B. Manufacturer's Mill Certificate: Certify that products meet or exceed specified requirements.

C. Mill Test Reports: showing structural strength, destructive and non-destructive test analysis and identification.

D. All certified welders employed on the work have been AWS qualified within the previous 12 months, in accordance with AWS-WHB-1.

E. Fabricator's and erector's qualifications.

F. Submit written welding procedures to Owner's testing agency for all welding on project. Procedures shall be in accordance with AWS pre-qualified welds. For welds not pre-qualified by AWS, provide project-specific procedures qualified by testing in accordance with AWS D1.1 to match actual materials, conditions, and orientations.

1.04 QUALITY ASSURANCE

A. Qualifications
   1. Fabricator: Company specializing in performing structural steel work minimum five years experience. Qualified fabricator who participates in the AISC Quality Certification Program and its designation as AISC-Certified Plant, Category Sbd Conventional steel building structures or Category Cbd for complex steel building structures.

   2. Erector: Company specializing in performing structural steel work with minimum five years experience.

   3. Erector: AISC Certified Erectors for Category CSE for steel and erection required.

   4. AWS Certified welders.

B. Fabricate structural steel members and perform work in accordance with AISC-M015L.

C. Perform welding in accordance with AWS D1.1 and California Building Code Section 2204.1.

D. Galvanized Structural Steel Coating applicator: Company specializing in hot-dip galvanizing after fabrication and following the procedures in the *Quality Assurance Manual* of the American Galvanizers Association.

1.05 FIELD MEASUREMENTS

A. Verify field measurements.

2. PRODUCTS

2.01 MATERIALS

A. Structural Steel Members: W-Shape Sections use ASTM A992 or ASTM A572 Grade 50 steel, as indicated on Structural Drawings.

B. Channels, Angles, Plates, Bars, M-Shapes and S-Shapes: ASTM A36.

C. Structural Tubing; ASTM A500, Grade B.

D. Bolts, Nuts and Washers: ASTM A307 galvanized to ASTM A153 for galvanized members, American National Course Threaded Series.

E. High Strength Bolts: ASTM A325 Slip-Critical, tension set high strength bolts, by Bristol Machine Co., Walnut, CA, or equal as approved in accordance with Division 01 for substitutions.

F. Welding Materials: AWS A5.1, E70XX, type and procedures required by electrode manufacturer for materials being welded.

G. Non-Shrink Grout: ASTM C1107, high performance, premixed compound consisting of non-metallic aggregate, cement, water reducing and plasticizing agents; capable of developing minimum compressive strength of 5,000 psi in 24 hours and 8,000 psi in 7 days; of consistency suitable for application and a 30 minute working time.

2.02 FINISH

A. Prepare structural component surfaces in accordance with SSPC SP-3 Power Tool Cleaning for embedded. Apply primer by brush or spray, minimum dry film thickness 3.0 mils.

B. Shop prime structural steel members. DO NOT prime surfaces that will be fireproofed, field welded, in contact with concrete or high strength bolted.
1. Clean surfaces to be primed, remove mill scale, grease, dirt and foreign matter. Two coats required for parts in contact but inaccessible for painting after erection.
2. Apply primer by brush or spray, minimum dry film thickness 3.0 mils. Thoroughly work into joints, angles and open spaces. Allow primer to dry and harden prior to handling for delivery to the site.
3. Clean contact surfaces immediately prior to assembly, leave unpainted.
4. Coat machined surfaces with approved removable coating to prevent corrosion.
5. After erection, clean field welds, field bolts and abraded portions and apply one additional brush spot coat using same paint material.
6. All surfaces scheduled to receive sprayed-applied fireproofing shall be free of lubricants, oils, paint or other matter that will impair adhesion of fireproofing.

C. Galvanize exposed exterior structural steel members where indicated to minimum Coating Grade 80 (1.9 oz/sq. ft.) in accordance with ASTM A123.

D. Galvanized items to be painted: Do not use quenching solutions or treatments immediately after galvanizing. Refer to individual sections for galvanized items to be painted.

D. All exterior steel exposed to weather conditions shall be shop galvanized or primed painted. Field painted in accordance with Section 09 90 00 Painting, High Performance Coatings.

3. EXECUTION

3.01 EXAMINATION

A. Verify that field conditions are acceptable and are ready to receive work.
1. Report discrepancies between drawings and field dimensions to Architect before commencing work.

B. Beginning of installation means erector accepts existing conditions and surfaces underlying or adjacent to work of this section.

3.02 FABRICATION

A. Fabricate and assemble structural steel in shop to greatest extent possible. Fabricate structural steel according to AISC specifications referenced in this Section and in Shop Drawings.

B. Camber structural steel members where indicated.

C. Identify high-strength structural steel according to ASTM A6 and maintain markings until steel has been erected.

D. Mark and match-mark materials for field assembly.

E. Fabricate for delivery a sequence that will expedite erection and minimize field handling of structural steel.

F. Complete structural steel assemblies, including welding of units, before starting shop-priming operations.

G. Comply with fabrication tolerance limits of AISC's "Code of Standard Practice for Steel Buildings and Bridges" for structural steel.

3.03 ERECTION

A. Allow for erection loads and stresses, and for sufficient temporary bracing to maintain structure safe, plumb and in true alignment until completion of erection and installation of permanent bracing. Provide bracing for dead and live loads and wind loads. Keep bracing in place until required to maintain safe conditions.

B. Contractor shall be responsible for correcting detailing and fabrication errors and for correct fitting of all members and components.

C. Field weld components and shear studs indicated on structural drawings.

D. Do not field cut or alter structural members without approval of Architect.

E. When approved, perform cutting, punching, drilling and tapping to accommodate work. Obtain accurate data as indicated on shop and erection drawings.

F. After erection, prime welds, abrasions and surfaces not shop primed except surfaces to be in contact with concrete.

G. Grout under base plates with the specified non-shrink grout.

H. Provide anchor bolts with templates and diagrams. Contractor shall be responsible for proper location and installation of bolts. Correct deficiencies or errors.

3.04 ERECTION TOLERANCES

A. Conform to AISC S325.

B. Maintain erection tolerances of Architecturally Exposed Structural Steel within AISC's "Code of Standard Practice for Steel Buildings and Bridges."

3.05 HIGH STRENGTH BOLTS

A. Allowable hole sizes: 1/16 inch larger than bolt size.

B. Use friction type connection with standard hardened steel circular, square or rectangular washer under bolt nut.

C. Thoroughly clean area under bolt head, nut and washer. Remove all paint, lacquer, oil or other coatings except organic zinc-rich paints in accordance with SSPC, SP-2.

D. Tighten bolts by power torque wrench or hand wrench until twist-off.

3.06 PUNCHING AND DRILLING

A. Punch material 1/16 inch larger than nominal diameter of bolt, wherever thickness of metal is equal to or less than the diameter of the bolt plus 1/8 inch.

B. Drill or sub-punch and ream where metal is equal to or more than the diameter of the bolt plus 1/8 inch. Make diameter for sub-punched and sub-drilled holes 1/16 inch larger than nominal diameter of bolt.

C. Precisely locate holes to ensure passage of bolt through assembled materials without drifting. Enlarge holes when necessary to receive bolts by reaming, flame cutting to enlarge holes is not acceptable. Poorly matched holes will be rejected.

D. Punch and ream holes to receive high strength bolts.

3.07 WELDING

A. Conform to AWS D1.1 and CBC Chapter 22A, Section 2204A.1.

B. Perform welding by direct electric arc process. Use operators certified within preceeding 12 month period as per AWS "Standard Qualification Procedure."

C. Chip welds to remove slag. Use wire brush to demonstrate uniformity of section, smoothness of welded metal, freedom from undercuts, overlays or feather edges and freedom from porosity and clinkers.

D. Visually inspect edges and ends of fillets and butt joint welds for indication of good fusion and penetration into base metal. Grind smooth all exposed welds.

E. Use of cutting torch will be allowed where metal being cut does not carry stress during the operations, and provided no stresses will be transmitted through a flame-cut surface. Make gas cuts smooth and regular in contour.

F. To determine effective width of members subjected to gas cutting, deduct 1/8 inch from width of gas cut edges. Make radius of gas cut fillets as large as practicable, but in no case less than one inch. Gas cutting to align bolt is not permitted.

3.08 CLEANING AND STRAIGHTENING

A. Before fabrication, thoroughly wire-brush material clean of scale and rust. Straighten by methods that will not injure materials.

B. After punching or working, remove twists or bends before parts are assembled. Make finished members free from twists, bends and open joints when erected.

C. Repair galvanized surfaces, where bare metal is exposed at weld sites and where shop finish is abraded or otherwise damaged, Use hot or cold repair process at contractor’s option, build-up zinc coating to minimum 5-mil thickness.

1. Cold Repair Process: ASTM A 780, A2 using ready mixed, fluid applied galvanizing repair compound.
2. Hot Repair Process: ASTM A 780, A1 using zinc-based alloys. Apply zinc solder while metal is still hot. Tin surface with zinc alloy and wire brush. Do not direct flame on alloy.

3.09 FITTING

A. Closely fit members, finished true to line and in precise position required to allow accurate erection and proper joining in the field.

B. Drilling to enlarge unfair holes will not be allowed. Light drifting to draw parts together will be permitted. Do not heat rolled sections, except for minor details.

3.010 QUALITY CONTROL

A. Required testing shall be performed under provisions of Division 01 and California Building Code Section 2212**.**

B. All complete penetration welds shall be subject to Ultrasonic Testing, as per AWS D1.1. All defective welds shall be repaired and retested with ultrasonic equipment at the Contractor's expense.

3.011 HANDLING

A. Both in shop and in field, transport, handle and erect to preclude damage or overstressing of any component.

3.012 FINISH

A. For exposed steel, field paint per Section 09 90 00 Painting with High Performance Coatings.

END OF SECTION

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements of Divisions 0 and 1 apply to work of this section.

1.2 RELATED SECTIONS

A. This section applies to all sections of Division 22, except as may be otherwise modified in each section.

1.3 FEES, PERMITS AND PAYMENTS

A. Fees, Permits and Payments: Contractor shall secure permits and inspections and pay full cost of same.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Work designated on drawing or specifications to be installed or performed by other sections of the inspections.

B. Finish painting: Equipment furnished shall be factory finished. If the factory finish is damaged during shipment, installation, etc., it shall be repainted by the Contractor subject to the Architect's approval.

C. Electrical connections for motors, line voltage wiring and conduit and low voltage wiring and conduit.

D. Individual motor controllers except when furnished as integral parts of packaged equipment.

1.5 EQUIPMENT RESTRICTIONS

A. The proprietary name, and/or model indicated on the drawings, or the first listed for a category in the specifications is the make and/or model used as the basis for design. Bids shall be based on the use of the products of the selected manufacturers. Substitutions will be considered as outlined in General Conditions and Division 1; Section, "Substitutions." Other acceptable manufacturers are named in these specifications.

B. Choice of Equipment: Equipment has been chosen, which will properly fit into the physical spaces provided and indicated, allowing ample room for access, serving, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with the code requirements and the requirements of the local inspection Department. Physical dimensions and arrangements of equipment to be installed shall be subject to the Owner's approval. Submit shop drawings of equipment layout for approval where equipment space does not comply with drawings. Changes in piping, motors, wiring, controls, structural or installation procedures required by the substituted product or equipment shall be made at no additional cost to the Owner, and with no reduction in scope.

C. Space Requirements:

1. In the preparation of drawings, a reasonable effort has been made to include equipment manufacturer's recommendations. Since space requirements and equipment arrangement vary according to manufacturer, the responsibility for initial access and proper fit rests with the Contractor. The final arrangement of the equipment and service connections shall allow the unit to be serviced. This shall include space to pull motors, filters, coils, tubes, etc. Make changes in piping and ductwork to suit actual installed equipment without further instructions or additional cost.
2. If the installation of the particular product or equipment, the Contractor has submitted, requires changes in material or size from that required in the contract drawings and specifications, such changes shall be submitted as shop drawings.
3. Contractor shall be aware that some equipment in the mechanical room must be in place before walls and/or roof is installed and shall schedule the installation of equipment accordingly.
4. Contractor shall pay the costs of design (3.0 x direct payroll) and installation of changes resulting from substitution of alternate products. Acceptance of alternate products by Architect does not change this requirement.

1.6 QUALITY ASSURANCE

A. Installer's Qualifications:

1. For the actual fabrication, installation, and testing of work, use only thoroughly trained and experienced workmen completely familiar with the items required and the manufacturers' current recommended methods of installation.
2. In acceptance of rejection of the finished installation, no allowance will be made for lack of skill on the part of the installers.

B. Certificates: Execute on behalf of the Owner and deliver to the Architect manufacturers' warranty certificates and instructions, etc. required to assure that the manufacturers' warranties are properly documented and in full effect for the warranty period.

1.7 CODES, ORDINANCES, REGULATIONS AND DEFINITIONS

A. Work and materials shall be in full accordance with the latest rules and regulations of the following Agencies and Codes, the Safety Orders of the Division of Industrial Safety; the California Mechanical Code; the California Plumbing Code; California Fire Code; the California Building Code; California Energy Conservation Code; city ordinances and other applicable laws or regulations.

B. Nothing in the drawings or specifications is to be constructed to permit work not conforming to these codes. Drawings and specifications shall take precedence when work and materials called for exceed code requirements.

C. References to Code Specifications shall mean editions in effect at date of proposals.

D. Reference to technical societies, trade organizations, governmental agencies are made in Mechanical Sections in accordance with the following abbreviations:

AABC	*Associated Air Balance Council National Standards for Field Measurement and Instrumentation, Total System Balance*
AGA	*American Gas Association*
AMCA	*Air Moving and Conditioning Association*
ANSI	*American National Standards Institute*

ARI	*Air Conditioning and Refrigeration Institute*
ASHRAE	*American Society of Heating, Refrigerating, and Air Conditioning Engineers*
ASTM	*American Society of Testing and Materials*
AWWA	*American Water Works Association*
CISPI	*Cast Iron Soil Pipe Institute*
ETL	*Electrical Testing Laboratory*
FM	*Factory Mutual*
IBC	*International Building Code*
ICC-ES	*International Code Council Evaluation Service*
IRI	*Industrial Risk Insurers*
ISO	*Insurance Service Organization*
NEBB	*National Environmental Balancing Bureau Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems*
NEC	*National Electrical Code*
NFC	*National Fire Codes*
NFPA	*National Fire Protection Association*
NRCA	*National Roofing Contractor's Association*
OSHPD	*Office of Statewide Health Planning and Development for the State of California*
PDI	*Plumbing and Drainage Institute*
SMACNA	*Sheet Metal and Air Conditioning*
UL	*Underwriter's Laboratories, Inc.*

E. Definitions:

APPROVED	*As approved by Owner's Representative.*
ARCHITECT / ENGINEER	*The Architect or Engineer of record for this project. The Architect or Engineer is the Owner's representative regarding preparation, revisions and interpretation of the contract documents.*
AS DIRECTED	*As directed by the Owner's Representative.*
AS REQUIRED	*As required by applicable Code requirements; by good business practice; by the conditions prevailing; by the Contract Documents; by Owner, or by Owner's Representative.*
AS SELECTED	*As selected by Owner's Representative.*
BATTERY	*Two or more fixtures served from same branch.*

BY OTHERS	*Work on this Project that is outside the Scope of Work to be performed by the Contractor under this Contract, but that will be performed by Owner, other Contractors or other means.*
CERTIFIED TEST REPORTS	*Test Reports signed by an authorized official stating that tests were performed in accordance with the test method specified that the results reported are accurate, and that items tested either meet or fail to meet the stated minimum requirements.*
CERTIFIED INSPECTION REPORTS	*Reports signed by approved Inspectors attesting that the items inspected meet the Specification requirements other than any exceptions included in the report.*
CONCEALED	*Embedded in masonry, concrete or other construction, installed within furred spaces, or in enclosures.*
EQUAL	*The Contract documents are based upon the manufacturer and model number indicated on the drawings or specifications. Bidder may propose alternative product but will be considered only if the bidder has submitted a base Bid, which is in accordance with the specified product. Alternate proposal shall include complete technical data and itemized price adjustments. Bidder shall assume the responsibility that the alternate product meets the physical, mechanical, electrical, structural, acoustical and architectural requirements of the specified product. Acceptance of an alternate product does not entitle the Contractor to a Change Order to modify architectural, structural, mechanical, electrical, control or any other systems necessary to accommodate the alternate product. The Owner or his representative may reject alternate products.*
EXPOSED	*Not installed underground or not concealed as defined above.*
FIELD TESTS	*Tests or analysis made at, or in the vicinity of the job site in connection with the actual construction.*
FURNISH	*Supply and deliver to the Project site only, not install (unless required to be installed elsewhere in the Contract Documents). Product must be delivered ready for installation and in operable condition.*
INSTALL	*Install (services or labor) only, not furnish (unless required to be furnished elsewhere in the Contract Documents). Install means to place in final position, complete, anchored, connected and ready to operate.*
LIFE SAFETY SYSTEMS	*Systems involved with fire protection: including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, fire dampers, and smoke exhaust.*

	Systems involved with and/or connected to emergency power supply: including generators, transfer switches, transformers, and circuits to fire protection, smoke evacuation, and emergency lighting systems.
	Medical and life support systems.
	Fresh air and relief systems on emergency smoke control sequence.
MAIN	*The principal artery of a system of continuous piping or ductwork, to which branches may be connected.*
MANUFACTURER'S DIRECTIONS, INSTRUCTIONS, RECOMMENDATIONS, SPECIFICATIONS	*Manufacturer's written directions, instructions, recommendations, specifications.*
PRODUCT	*Materials, systems, equipment and fixtures.*
MANUFACTURER'S CERTIFICATE CONFORMANCE	*A certificate signed by an authorized manufacturer's official attesting that the material or equipment delivered meets the specification requirements. Manufacturer's representative certificate is not acceptable.*
MUST; SHALL; TO; WILL	*When used as a directive to the Contractor, these items indicate a mandatory action.*
NECESSARY	*Essential to completion of work.*
OWNER-FURNISHED, CONTRACTOR-INSTALLED	*To be furnished by the Owner at its cost and installed by the Contractor as part of the work.*
PROVIDE	*Shall include "Furnish and install" which means supply, fabricate, deliver, place and connect, complete in place, ready for operational use. When neither furnish, install or provide is stated, "provide" is implied.*
REMOVE	*To remove item completely including attachments, frames, anchors, fittings, bases, pipes, conduits and supports, capping behind finished surfaces and repairing floors, bases and walls to match color and texture and be smooth with existing adjacent surfaces.*
RISER	*A vertical waterline supplying two or more fixtures, or batteries of fixtures located in different rooms.*
SHOWN	*As indicated on the Drawings.*
SPECIFIED	*As written in the Contract Documents.*
SUBMIT	*Submit to Owner's Representative.*
TESTING LABORATORY	*A person or organization whose functions include*

testing, analyzing or inspection products and/or evaluating the designs or specifications of such products according to the requirements of applicable standards.

WORK — *Work of the Contractor or Subcontractor includes labor or materials (including, without limitation, without equipment and appliance) or both, incorporated in, or to be incorporated in the construction covered by the complete Contract.*

1.8 SEISMIC RESTRAINT

A. Design, furnish, and install attachment devices, anchor bolts, and seismic restraints that are required for seismic compliance for all equipment, apparatus, piping, conduit and raceways, ductwork, and other components of the specified systems required by reference codes and standards.

B. Provide seismic restraint types as described. If the item to be restrained is not listed, select appropriate restraint and submit for approval.

C. Provide seismic bracing for mechanical, plumbing, and fire protection systems.

D. Seismic Restraints Requirements
   1. For each seismic restraint, provide certified calculations to verify adequacy to meet the following design requirements:
   2. Ability to accommodate relative seismic displacements of supported item between points of support.
   3. Ability to accommodate the required seismic forces.
   4. For each respective set of anchor bolts provide calculations to verify adequacy to meet combined seismic-induced sheer and tension forces.
   5. For each weld between structure and item subject to seismic force, provide calculations to verify adequacy.
   6. Restraints shall maintain the restrained item in a captive position without short circuiting the vibration isolation.

1.9 SUBMITTALS

A. General: Refer to Division 1.

B. Project Drawings:
   1. The drawings are diagrammatic and indicate the general layout of the equipment.
   2. The exact location shall be field determined, after shop drawing review for the installation in available space at the job site.

C. Equipment Lists and Equipment Brochures and Shop Drawings.
   1. Copies: Submit six copies of data as specified hereafter.
   2. Items of material and equipment required by this Division shall be reviewed by the Architect prior to the start of work. The Contractor shall submit items requiring such review, allowing ample time for the checking and processing, and shall assume responsibility for delays incurred due to the rejected items. Rejected items shall be resubmitted as specified only. Submittal information covering items shall be neatly bound together into booklets, each booklet containing individual items specified. Separate submittals of individual items are not allowed. Each submittal item shall be identified with

the governing specification section, paragraph, subparagraph, or reference drawings, as applicable.

3. Equipment Lists: Provide name of manufacturer, brand name, and catalog number of each item. Submit complete submittals, at one time, having items arranged in numerical sequence with each item identified by section and article of the specifications. Listing items “as specified” without both name and model or type designation is not acceptable, except pipe and fitting not specified by brand names may be listed “as specified” without manufacturer’s name, provided proposed materials comply with specification requirements.
4. Material Brochures: Provide copies of complete description, information and performance data covering materials and equipment, which are specified. Brochures submitted to the Architect shall be published by the manufacturers and shall contain complete and detailed engineering and dimensional information. Brochures not compiled in the following manner shall be returned for re-submittal. Brochures submitted shall contain only information relevant to the particular equipment or materials to be furnished. The Contractor shall not submit catalogs, which describe several different items other than those items to be used unless all irrelevant information is marked out, or unless relevant information is clearly marked. Brochures from each manufacturer shall be identified.
5. Shop Drawings:
    a. Refer to Divisions 0 and 1.
    b. Provide additional data as specified in Governing Specification Section.
6. Seismic Restraint
    a. Shop Drawings
        1) Where walls and slabs are used as seismic restraint locations, provide details of acceptable methods for restraint of equipment, ducts, conduit and pipe shall be included, with supporting certified calculations.
        2) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
        3) A copy of the coordination or contract drawings shall be marked-up with the specific locations and types of restraints shown for pipe, duct, and equipment. Rod bracing and assigned load at each restraint location shall be clearly delineated. Each drawing shall be signed by the same engineer performing the seismic calculations noted below.
        4) For ceiling suspended equipment, provide minimum and maximum installation angle allowed for restraint system, as well as braced and un-braced rod lengths at each allowable installation condition.
    b. Seismic Certification and Analysis
        1) Seismic restraint calculations shall be provided for connections of equipment to the structure. Performance of products (such as: strut, cable, anchors, clips, etc.) associated with restraints shall be supported with manufacturer’s data sheets or certified calculations. Seismic calculation shall be certified by a Professional Structural or Civil Engineer registered in the State of the project.
        2) Seismic restraint calculations shall be based on the acceleration criteria required by local codes. Note: For roof-mounted equipment, both the seismic acceleration and wind loads shall be calculated; the highest load shall be utilized for the design of the restraints and isolators.
        3) Calculations to support seismic restraints designs shall be stamped by a professional engineer who is registered in the state where the work is being performed, with at least five years of seismic design experience.
        4) Table elevations refer to the structural point of attachment of the equipment support system (i.e., use floor slab for floor supported equipment and the elevation of the slab above for suspended equipment).

5) Analysis shall indicate calculated dead loads, derived loads, and materials utilized for connections to equipment and structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/or weld length.

c. Product Data: For the following:
   1) Include rated load, rated deflection, and overload capacity for each vibration isolation device.
   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 OSHPD or an agency acceptable to authorities having jurisdiction.
      b) Annotate to indicate application of each product submitted and compliance with requirements.
   3) Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

d. Delegated-Design Submittal: For 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 with at least five years of seismic design experience responsible for their preparation.
   1) Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
      a) Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 15 Sections for equipment mounted outdoors.
   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.
   4) Seismic-Restraint Details:
      a) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
      b) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
      c) Coordinate seismic-restraint and vibration isolation details with wind restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
      d) Preapproval and Evaluation Documentation: By OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

e. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

f. Welding certificates.

g. Qualification Data: For professional engineer and testing agency.

h. Field quality-control test reports.

7. Miscellaneous: Prior to installation, submit to Construction Supervisor on the job site, two copies of the following:

a. Shop Drawings of equipment layouts
b. Installation instructions for each piece of mechanical equipment furnished.
c. Dimension drawings for mechanical equipment pads and curbs including bolt sizes and locations.

8. Submittals required by these specifications, include drawings, calculations, brochures, samples, etc. shall be submitted as one package. Partial submittals will be returned unprocessed.

D. Record Drawings and Operating and Maintenance Books

1. Record Drawings (Refer to Division 1): On completion of work, furnish the Owner through the Architect, with a complete set electronic record drawings and shop drawings which properly reflect the locations of all equipment, fixtures, piping, ductwork, diffusers, mixing boxes, controls, etc., as actually installed. Where necessary to locate concealed equipment, dimensions, shall be included on these drawings. Maintain a separate set of drawing prints at the job site for such marking of "As-Built" locations. This set shall be updated as the installation work progresses and shall be available to the Architect at job visits. The Contractor shall indicate on the "As-Built" Drawings all deletions in green. Additions, relocations, rerouting and modifications shall be indicated in red.
2. The format shall be AutoCad 2010 or later. A CD with the electronic model will be supplied to the successful bidder for this purpose. Monthly changes shall be made to the drawings on a layer named "record" and the color shall be green. A copy of the model on CD with any "as-built" changes shall be submitted to the Architect along with all payment applications.
3. At the end of the project, the Contractor shall take "as-built" drawings modifying the electronic drawing files to show all changes, modification or additions made during construction. These drawings will become "Record Drawings" to be delivered to the Architect.
4. Final Record Drawings shall include legends, schedules, plans, sections and details.
5. Record Drawings shall be marked on the lower right corner with the following:
   a. Name of Contractor
   b. Record Drawings
   c. Date
   d. Building Permit Number
   e. Letter shall be bold and print 1/4 inches high minimum.
6. Contractor shall submit to the Architect, Record Drawings as follows:
   a. Four CDs (AutoCad 2014 or later)
   b. One reproducible set of drawings
   c. Four sets of drawings
7. The Architect will distribute the final Record Drawings as follows:

	OWNER	ARCHITECT	ENGINEER
CDs	1	1	1
Reproducible drawing set	1	0	0
Drawing Sets	1	1	1

8. Delivery of complete set of Record Drawings is one condition for the release of Contractor's final payment under the Contract.

E. Operating and Maintenance Books

1. Operating and Maintenance Books (Refer to Division 1): Provide the Owner through the Architect, operating instructions and maintenance data books for all equipment and materials furnished under this Division.
2. Submit five copies of operating and maintenance data books to the Architect for review two weeks before final inspection of the project. Assemble data in a single complete

indexed volume and identify the size, model and features indicated for each item, as follows:

a. Identification readable from the outside of the cover, stating “Heating, Ventilating and Air Conditioning and/or Plumbing and/or Fire Protection Installation. Owner, by (name of company).”
b. Neatly typewritten index near the front of the manual, furnishing immediate information as to location in the manual of emergency data regarding the installation.
c. Complete instructions regarding the operation and maintenance of all equipment involved.
d. Complete nomenclature of replaceable parts, their part numbers, current cost and name and address of the nearest vendor of replacement parts.
e. Valve identification table keyed to valve I.D. number (e.g. V-1) on brass tag attached to each valve. Table shall indicate type of valve, product or service (e.g. domestic cold water), and function (e.g. shut-off, balancing, etc.).
f. Copy of guarantees and warranties issued on the installation showing dates of expiration.

1.10 EXPLANATION AND PRECEDENCE OF DRAWINGS

A. For purpose of clearness and legibility, the drawings are essentially diagrammatic although size and location of equipment is drawn to scale wherever possible. The Contractor shall make use of data in contract documents and shall verify this information at building site.

B. Attention is called to the inclusion of flow diagrams, riser diagrams and details. Diagrams are not for the purpose of giving physical dimensions or locations, but rather to clarify sizes and the interconnections of the piping and of the various units of the process.

C. Other drawings of the contract set are hereby made a part of these specifications and shall be consulted by the Contractor and his work adjusted to meet the installation conditions.

D. Drawings indicate required size and termination of pipes and ducts and suggest proper routes of piping and duct to conform to the structure, to avoid obstructions and to preserve clearance. However, it is not the intention to indicate necessary offsets and it shall be the responsibility of the Contractor, under this section, to install ductwork and piping in such a manner as to conform to structure, avoid obstructions, preserve headroom, keeping openings and passageways clear, and make equipment requiring inspection, maintenance and repair accessible without further instructions or extra cost to the Owner.

E. Changes in location on piping, apparatus and equipment as indicated on the drawings shall be made to meet the architectural and structural conditions as required and acceptable to the Architect. Changes in work which has not been installed shall be made by Contractor without additional compensation, except changes which are caused by architectural and structural changes which increase the lengths of pipe or duct runs.

F. Contractor shall coordinate with other trades so that no interferences shall occur, as no extras will be allowed for changes made necessary by interferences with the work between trades.

G. CAD files plots and reproductions for this project are the property and instruments of service of d’Autremont-Helms & Associates, (dHA). dHA reserves and retains copyright authority, privileges and rights.
   1. Upon request and subject to some limitations dHA with their client’s approval, may allow contractors and/or vendors to acquire and use copies of the electronic media file data for preparation of:
      a. Fabrication of shop drawings for this project.
      b. Submittals pertaining to this project.

c. Record documents.

2. Applicable limitations include:
   a. The Contractor or vendor acquiring these files agrees to hold harmless dHA the Architect and Owner from liability and/or damages resulting from their use.
   b. The Contractor or vendor acquiring these data files assumes full responsibility for their use and for the correctness of any information or features contained therein.
   c. dHA does not warranty, (explicit or implied) the accuracy of the building backgrounds, or dimensions or features contained therein.
   d. Usage is limited to this specific project and the specific acquirer.
   e. The files are released solely for the convenience of the contractor or vendor acquiring same and CAD files may not be transferred to third parties without written prior approval.
   f. dHA shall remove seals, proprietary identification, etc.

1.11 COMPLETE PERFORMANCE OF WORK

A. Practices of the Trades: Work shall be executed in strict accordance with the best practice of the trades by competent workmen.

B. Complete Functioning of Work: Labor, materials, apparatus, and appliances essential to the complete functioning of the systems described and/or indicated, or which may be reasonably implied as essential, whether mentioned in these contract documents or not, shall be furnished and installed by the Contractor. In cases of doubt as to the work intended, or in the event of need for explanation thereof, the Contractor shall call upon the Architect for supplemental instructions.

C. Work not shown in complete details shall be installed in conformance with accepted standard practice.

1.12 CONTROL AND OBSERVATION

A. The Architect and Owner shall have the right to reject materials or workmanship, which in their opinion are not in accordance with this contract, to interpret contract provisions and the meaning of the drawings and specifications. The above named parties shall be allowed access to the work for observation at all times.

B. Defective work or work contrary to the contract documents may be rejected without regard to state of completion, even though said work has been accepted as a result of a previous observation.

1.13 APROVALS

A. Electrical equipment shall meet the listing requirements and bear a minimum of one of the following agency labels:
   1. Underwriter’s Laboratories (UL)
   2. Electrical Testing Laboratories (ETL)

B. No equipment will be accepted on the jobsite without prior written approval.

1.14 GUARANTEES

A. In addition to specific guarantees mentioned in these specifications, the Contractor shall leave the entire installation in complete working order and fee from defects in materials, workmanship or finish. Contractor shall repair or replace at his own expense work or parts of

work that may develop defects due to faulty material or workmanship during the tests and within a period of one year after the work is accepted by the Owner. Contractor shall guarantee also to repair or replace with like materials existing work of the building or equipment, which is damaged during the repairing of such defective apparatus, materials or workmanship. The signing of the contract for his work covered by these specifications and of which they shall become a part, shall become a written guarantee on the part of the Contract to carry out the provisions of this section of these specifications.

1.15 SEISMIC RESTRAINT QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the CBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer with at least five years of seismic design experience.

1.16 DAMAGE BY LEAKS

A. During the time period from the date of contract until termination date of this guarantee, the Contractor shall be responsible for damages to the ground, walls, roads, building, piping systems, electrical systems, heating, ventilating and air conditioning systems, building equipment, furniture and other building contents caused by leaks in the piping systems or equipment being installed or having been installed by him. Repair work shall be done as directed by, in a manner satisfactory to the Owner at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Standard of Quality: Materials and equipment shall be new and in good condition. The commercially standard items of equipment and the specific names mentioned in sections of Division 22 are intended to establish the standards of quality and performance necessary for the proper functioning of the mechanical work.

B. Variations: Since manufacturing methods vary, reasonable minor equipment variations are expected; however, performance and material requirements are minimum. The Architect retains the right to judge equality of equipment that deviates from the specifications.

C. Symbols are for identification. Symbols, capacities, sizes, and electrical characteristics are indicated on the drawings. Contractor shall make necessary provisions for installation of his equipment and for attaching or connecting his work to other trades.

2.2 FLASHINGS

A. Make pipes and vents passing through roof or outside wall waterproof with flashings and storm collars or counter flashings.

B. Except as otherwise noted or required, extend vent pipes passing through roof at least 12 inches above finished roofline.

C. Furnish and install on each pipe passing through the roof a galvanized sheet metal flashing assembly with eight-inch skirt.

D. Furnish and install on each pipe passing through the roof a six-pound seamless lead flashing assembly with eight-inch skirt. Flashing shall have steel reinforced conical boot and be complete with open top cast iron counter flashing and permaseal waterproofing compound. For sanitary vent, provide a hood with a minimum 2 to 1 free area to vent pipe size.

2.3 PIPE SLEEVES

A. Provide pipe sleeves for mechanical piping.

B. Size pipe sleeves to permit placing pipe and specified isolation material for pipes passing through concrete or masonry walls or concrete slabs.

C. Sleeve for pipes through floor slabs standard weight black steel pipe with top of sleeve projecting 3” above finished floor. For waterproof sleeves, use J.R. Smith Fig. 172 or equivalent by Zurn or Josam.

D. Sleeves for pipes through walls shall standard weight black steel Schedule 40 pipe with ends flush with wall surfaces.

E. Seal pipes passing through fire rated walls or roofs. Use Dow Corning 3-6548 Silicone RTV Foam in the annular space between pipes and sleeves. Sealant through fire rated walls or roofs shall be rated with the same fire rating as the wall or roof.

F. Insulated pipe shall be insulated in sleeves, caulked and sealed as above. Use type CS-CW inserts as manufactured by Pipe Shields, Inc.

G. Pipes passing through exterior walls and concrete walls shall be sealed watertight with “Linkseal” as manufactured by Thunderline Corp. Method of installation as recommended by the manufacturer.

2.4 PIPE ISOLATORS AND COVERING PROTECTION

A. Pipe isolators: Provide each hanger or clamp for un-insulated piping with an isolation material, having metal backing, to isolate sound vibration and electrolysis. Provide Elcen “Isolator or appeared equal.” Isolator not required for fire protection automatic sprinkler piping, waste, vent and natural gas piping.

2.5 ESCUTCHEONS

A. Provide heavy chrome-plated or nickel plated plates or approved pattern on pipe passing through floors, walls and ceilings in finished areas. Escutcheons shall be chrome-plated steel plates with concealed hinges and setscrew. Pattern shall be approved by the Architect.

2.6 CORROSION PROTECTION

A. Prior to delivery to the job site, wrap buried steel pipe with corrosion protective wrap of pressure sensitive polyvinyl chloride or polyethylene tape applied after pipe has been thoroughly cleaned. Tape shall be nominal thickness of 20-mil consisting of one layer of 20-mil tape or two separate layers of 10-mil tape. Apply with suitable primer adhesive recommended by manufacturer.

B. Tightly apply tapes with 1/2-inch minimum uniform lap, free from wrinkles and voids. Use approved wrapping machines and experienced operators.

C. Tapes: "Chasekote" No. 775, Plicoflex No. 340-25, Polyker 922 and 923, "Scotchwrap" No. 51 or equal. Apply tape after pipe is cleaned as recommended by the tape manufacturer.

D. Cover filed joints and fittings by wrapping polyethylene or polyvinyl tape specified for wrapping piping, except use two layers of 10-mil thick tape. Wrap joints to provide minimum of six-inches over adjacent pipe covering. Where fittings are wrapped, width of tape shall not exceed two inches. Apply adequate tension so tape will conform tightly to contours of fittings. Use putty tape insulation compounds such as "Scotchfil" or equal to fill voids and provide smooth even surface for application of tape wrap.

E. Alternate: In lieu of tape wrap, factory applied plastic coating on steel pipe will be acceptable. Use tapes for field joints, fittings and valves same as specified above. Pipe Coating: "X-Tru Coat" (20-mil thick) as manufactured by Standard Pipe Protection, Republic, Pipe Line Service Corp., Scotchkote 202 (12-mil thick) as manufactured by 3M Company, or equal, with "X-Tru-Tape", or equal, for joints and valves.

F. Test wrapped or coated pipe, fittings and field joints on job site, after assembly, with approved high voltage holiday detector Tinker and Rasor, or equal, with positive signaling device to indicate any flaws, holes or breaks in wrapping. Set peak voltage to 10,000-Volt. If Scotchkote 202 is used, set peak voltage to 1,000-Volt. Place piping on temporary blocks to allow testing to run along underside of pipe. Repair defects before covering. Conduct testing in presence of Architect.

G. No special precautions are required for copper or plastic piping below grade.

H. Special wrapping is required for contact with concrete such as thrust blocks or floor slabs. Piping shall be wrapped with minimum 8-mil thick polyethylene plastic sheets.

2.7 ACCESS COVERS AND ACCESS DOORS

A. Access covers and doors locations shall coordinate with Architect.

B. Provide access covers over under floor buried mechanical valves, controls, clean outs, located in interior and exterior floor and grade areas.

C. Provide access door over concealed mechanical valves, controls, duct coils, dampers, fire dampers, pipe chases, concealed mechanical equipment through fire rated walls and ceilings.

D. Provide access doors for access to mechanical equipment valves.

E. Provide rated access covers or doors when required by the ceiling and wall fire rating.

F. Access covers – Interior concrete floors:
   1. Type: Square or rectangular frame with hinged and secured cover.
   2. Size: Nominal 10 x 10-inch.

3. Construction: Aluminum alloy frame and hinged score rated XH cover with lifting device. Secure with vandal proof screws.
4. Marking: Cast cover with words “CLEANOUT”, “GAS SHUT-OFF” or “WATER SHUT-OFF” when used for these services.
5. Acceptable manufacturers: Smith No. 4915, Zurn, Josam.

G. Access Covers – Interior vinyl floors:
1. Type: Square or rectangular frame with recessed cover.
2. Size: Nominal 10 x 10-inch.
3. Construction: Aluminum alloy frame and tile recess XH cover with lifting device. Secure with vandal proof screws at each corner.
4. Acceptable manufacturers: Smith No. 4920, Zurn, Josam.

H. Access Doors – Walls and ceilings:
1. Type: Flush or recessed panel.
2. Size: Minimum 12 x 12-inch nominal door for hand access, minimum 16 x 20-inch nominal door for personal access.
3. Location and style:

Masonry/concrete walls	Milcor “M” Standard
Gypsum wallboard walls and ceilings	Milcor “M” Standard
Plastered surfaces (except toilet walls)	Milcor “K” Standard
Tile/terrazzo/toilet room walls (with casing bead stainless)	Milcor “M” Standard
Acoustical tile (check type of ceiling system)	Milcor “A”
General areas	Milcor “M” Standard
Fire rated shafts, rated walls and ceilings	Milcor “B” Standard

4. Material:
a. Stainless Steel, No. 302 with No. 4 finish.
b. Standard manufacturer’s standard construction and finish for type specified.
5. Locking:
a. Screwdriver: Flush screwdriver operated with case hardened cam.
6. Acceptable Manufacturers Milcor, Zurn, Miami, Carey, Potter-Roemer.

2.8 SEISMIC-RESTRAINT DEVICES

A. Basis-of-Design Product and Systems: Subject to compliance with requirements, provide Mason Industries or a comparable product by one of the following:
1. Kinetics Noise Control
2. Loos & Co.; Cableware Division
3. Mason Industries
4. TOLCO Incorporated; a brand of NIBCO INC.

B. Provide seismic restraints and seismic bracing equipment and systems as described in Part 3 and the Mason Industries Seismic Restraint Guidelines for acceptable restraint methods and OSHPD approved details.

C. Seismic Restraint Types
1. Type I: Restrained Spring Mount, Mason SLR-A. Isolator shall incorporate snubbing restraint in all directions, and be capable of supporting equipment at fixed elevations during installation.

2. Type II: Resilient Seismic Snubber. Mason Z-1011. Each corner or side of equipment base shall incorporate a seismic restraint having a minimum of 5/8-inch thick, all directional resilient pad limit stop. Restraints shall be fabricated of plate, structural members or square metal tubing. Angle bumpers are not acceptable.
3. Type III: Cable or Brace Restraint. Mason SCB and SSB. Multiple metal cable or steel strut type with approved fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members using two sided beam clamps or appropriately designed inserts for concrete.
4. Type IV: Spring Neoprent Hanger. Mason 30N. Double deflection neoprene isolator min. 0.15-inch encased in ductile iron or steel casing.
5. Type V: Non-isolated equipment shall be field bolted or welded (powder shots not acceptable) to the structures as required to meet seismic forces. Bolt diameter, imbedment data, and/or weld length must be shown in certified calculations as noted above.

D. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by OSHPD or 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 four times the maximum seismic forces to which they will be subjected.

E. 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 air gap, and minimum 1/4-inch thick resilient cushion.

F. Channel Support System: 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.

G. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

H. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

I. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

J. 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.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water resistant neoprene, with a flat washer face.

L. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

M. 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 E 488.

N. Factory Finishes
   1. Finish: Manufacturer's standard prime-coat finish ready for field painting.
   2. Finish: Manufacturer's standard paint applied to factory-assembled and - tested equipment before shipping.
      a. Powder coating on springs and housings.
      b. Hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
      c. Baked enamel or powder coat for metal components on isolators for interior use.
      d. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 SUPERVISION

A. The Contractor shall furnish the services of a Superintendent experienced in the work of each section who shall be constantly in charge of the progress of the work, together with all the necessary journeymen, helpers and laborers required to properly unload, erect, connect, adjust, start, operate and test the work involved.

3.2 PROTECTION, CARE AND CLEANING

A. The premises shall be maintained as required by Division 1.

B. Materials and Equipment:
   1. Effectively protect materials and equipment to be installed on a project against moisture, dirt and damage during the construction period, to the entire satisfaction of the Owner. Special care shall be taken to provide protective and similar equipment that are particularly vulnerable to grit and dirt.
   2. Keep interior of ductwork free of dirt, grit, dust, installation and other foreign materials. Do not operate air distribution equipment until building is cleaned and air filters installed in order to prevent soiling of diffusers, ducts, air handling equipment, and buildings. Provide new set of filters after final acceptance of air distribution systems.
   3. Drain and flush piping to remove grease and foreign matter. Thoroughly clean out valves, traps, strainers, and demonstrate the cleanliness to the Owner.

3.3 DISPOSITION OF MATERIALS

A. Refer to Divisions 1 and 2.

3.4 CLEAN-UP

A. Debris and Rubbish: Remove and transport debris and rubbish in a manner that will prevent spillage on pavement, streets, or adjacent areas. Limits to 3/4-cubic yard capacity buggies or other conveyances used roofs and within the building to transport removed debris. Clean up spillage from pavement, streets and adjacent areas.

3.5 INSTALLATION

A. General: Inspect the architectural, structural, plumbing, fire protection, special systems and HVAC drawings and specifications to become familiar with the building construction and to coordinate with the work of others.

B. Piping: Install in strict accordance with manufacturer's written installation instructions and recommendations. Install in a manner that permits expansion and contraction caused by changes in temperature and pressure. Provide additional support as required. Run pipes straight and true, parallel to or at right angles to the building walls. Springing or forcing piping into place will not be permitted.

C. Fixtures and Equipment: Install in strict accordance with manufacturer's written installation instructions and recommendations. Fixtures (except for handicapped) shall be roughed in only from fixture manufacturer's certified "Rough-In Measurement Drawings" which shall be submitted to the Architect for approval. Handicapped fixtures shall be installed in accordance with 2007 California Building Code rough-in measurements adjusted from manufacturer's certified drawings.

3.6 STAGING AND HOISTING

A. Provide hoisting equipment, staging scaffold, ladders, barricades, shores or similar facilities required to properly carry out this work in accordance with all safety regulations.

3.7 EXCAVATION AND BACKFILL

A. The Contractor shall do necessary excavations and backfill for the installation of work included in his contract.

B. Excavation: Bury piping outside the building to a depth of not less than 3-ft below finish grade unless otherwise noted.

C. Excavations shall be as narrow as possible and shall be braced and supported as prescribed by the State Industrial Safety Commission. Excavations shall be cleared of roots and other organic substances and debris. Debris and surplus earth shall be removed from the site. Excavations shall be maintained free of water.

D. Backfill shall not be more than six-inch thick layers of properly dampened and solidly iron tamped approved earth or backfill material to a density of 90% compaction. Compacting by pudding will not be permitted.

3.8 ENCLOSURES AND BARRICADES

A. The Contractor shall provide, install and maintain for the duration of the work as required, lawful and necessary barricades and railings, lights, warning signs and signals and shall take other precautions as may be required to safeguard persons, the site and adjoining property, including improvements thereon, against injuries and damages of every nature whatsoever. This requirement applies continuously (24-hours, 7-days a week) for the duration of this contract and is not limited only to regular working hours.

3.9 CONTROL AND INSPECTION

A. The Architect or Owner shall have the right to reject materials and workmanship which in his opinion are not in accordance with this contract, to interpret contract provisions and the meaning of the drawings and specifications.

B. The above named parties shall be allowed access to the work for observations at all times.

C. Defective work contrary to the contract documents may be rejected without regard to state of completion, even though said work has not been rejected as a result of a previous observation.

3.10 SLEEVES, CUTTING AND PATCHING

A. The Contractor shall be responsible for the sizing and timely placing of sleeves of piping and insulation material passing through walls, partitions, beams, floors and roof while same are under construction. If a pipe is insulated, its pipe sleeve shall be larger than the outside diameter of the insulation around the pipe. Sleeves set in concrete floor construction shall be minimum 20-gage galvanized steel. If holes and/or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no expense to the Owner by parties approved by the Architect.

B. Openings into existing masonry shall be core drilled or saw cut. The Contractor shall undertake no cutting or patching without first securing the Architect's written approval. Where a pipe passes through a sleeve, provide 1/2-inch minimum clearance. No joint of the pipe (or its insulation) shall touch the sleeve. Caulk around such pipe with sufficient layers of 1/8-inch neoprene and seal off opening between pipe and sleeve with non-hardening mastic.

C. Caulking in fire walls or floors shall be made using a UL listed, fire-rated material. For pipe or conduit penetrations through fire rated floors, walls, partitions, ceilings, etc., provide firestop system complying with the UL "Fire Resistance Directory" for "Through Penetration Firestop Systems" (XHEZ).

3.11 ANCHOR BOLTS

A. Furnish and install anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts shall be of the size and number recommended by the manufacturer of the equipment and shall be located by means of suitable templates. When equipment is placed on vibration isolators, the equipment shall be secured to the isolator and the isolator to the floor, pad, or support as recommended by the vibration isolation Manufacturer.

3.12 INSTALLATION OF VALVES

A. General:
   1. Valves shall be full line size unless otherwise noted. Automatic control valves are exempted.
   2. Valves shall have proper clearances for handle operation and shall close tight at the specified test pressure.
   3. Pump discharge check valves shall be of non-slam type.

B. Arrangement
   1. Valves shall be installed in the systems so located, arranged and operated as to give complete regulation of apparatus, equipment and fixtures.
   2. Valves shall be installed for accessibility and easy maintenance.
   3. Gate valves shall be installed with stems horizontal to vertically upright.
   4. Provide valve box at each valve in ground. Set cover flush with finished grade except in planted areas set 1-inch above grade.
   5. Balance Valves: Install balance valves where shown and on each circulating return branch where two or more branches occur on domestic hot water system.

6. Provide readily accessible lubricated gas shut-off valve in gas supply to each gas burning appliance and ahead of union connection thereto, and in addition to valves on the appliance. Locate within 3-ft 10-inch of appliance.
7. Compression Stops: Install stop valve or compression stop on water supply lines to each plumbing fixture, including hose faucets. Where fixture from trim is specified with integral built-in stops, individual supply stops will not be required. Unions are not required adjacent to compression stops.
8. Hose Faucets: Mount with outlet 18-inch above finished grade or 12-inch above finished floor, unless shown otherwise.

C. Location:
1. In branches and/or headers of water piping serving a group of two or more plumbing fixtures.
2. On both inlet and outlet of all apparatus and equipment.
3. For shutoff of branch mains.
4. For flushing and sterilizing the systems.
5. Where shown on the drawings.
6. Ahead of each automatic control or regulation valve in water lines.

3.13 PIPE SUPPORTS

A. Installation:
1. Securely support piping from building construction with manufactured iron hangers, brackets, trapezes, guides, anchors and sway braces to maintain pipe alignment and prevent sagging, noise and excessive strain due to uncontrolled movement under operating conditions. Auxiliary secondary beams shall be furnished and installed under this division of the specifications wherever necessary to meet the requirements above.
2. Piping supports for each system shall be engineered as a system and the proposed system submitted for review.
3. Relocate hangers as necessary to correct unsatisfactory conditions that may become evident when system is put into operation.
4. Support of piping by wire, rope, wood or other make shift devices will not be permitted.
5. Burning of holes in beam flanges or narrow members will not be permitted.
6. Where calculated maximum travel due to thermal expansion exceeds 1 inch, provide rollers at supports.
7. Piping shall not be supported from roof decking. Furnish and install auxiliary steel members to span steel purlins to distribute the load. Refer to roof shop drawings for location of beams and purlins.
8. Sheet lead, lead wool or wood plugs shall not be accepted as a substitute of cinch anchors as a means of attaching materials and equipment to concrete.
9. Support for insulated pipe shall be outside the insulation. Protect pipe insulation at every hanger, support or guide with inserts and shields. The galvanized sheet shield shall be applied between the hanger or support and the pipe insulation. Provide saddles at all rollers of insulated pipe not equipped with inserts and shields.

3.14 SEISMIC RESTRAINT

A. Examination
1. 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.

2. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Applications
1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by OSHPD or an agency acceptable to authorities having jurisdiction.
2. 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.
3. 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.

C. Seismic Restraint Installation
1. Install seismic restraint devices as necessary to meet AHJ requirements.
2. Piping Restraints:
   a. Comply with requirements in MSS SP-127.
   b. Space lateral supports a maximum of 40-ft on center, and longitudinal supports a maximum of 80-ft on center.
   c. Brace a change of direction longer than 12-ft.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install seismic-restraint devices using methods approved by OSHPD or an agency acceptable to authorities having jurisdiction providing required submittals for component.
5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
6. 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.
7. 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.
8. Drilled-in Anchors:
   a. 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.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. 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.
   d. 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.
   e. Set anchors to manufacturer's recommended torque, using a torque wrench.
   f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
9. Seismic Restraint Application
   a. Suspended pipe, duct, cable trays, bus duct and conduit shall be restraint Type III or V.

b. For trapeze supported piping and conduit, the individual pipes and conduits shall be transversely and vertically restrained to the trapeze support at each restraint location.
c. For overhead supported components, overstress of the building structure must not occur. Bracing shall occur from:
    1) Flanges of structural beams
    2) Upper truss chords in bar joists.
    3) Cast in place inserts or drilled and shielded inserts in concrete structures.
d. Pipe Risers
    1) Where pipes pass through cored holes, core diameters shall be a maximum of 2-inch larger than pipe O.D. including insulation. Cored holes must be packed with resilient material or firestop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required.
    2) Non-isolated, constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of slab attached in a seismically approved manner for vertical restraint.
    3) Isolated and/or variable temperature risers through cored holes require Type K riser resilient Guides and Anchors installed to meet both thermal expansion and seismic acceleration criteria. Each floor level shall have either a riser clamp that does not interfere with the thermal expansion/contraction of the pipe or a riser clamp/cable assembly (also non-interfering) capable of supporting the weight of the pipe between floors in the event of pipe joint failure. Riser guides and anchors shall also be selected to serve as seismic restraints.
e. Chimneys, stacks and boiler breaching passing through floors shall be bolted at each floor level or secured above and below each floor with riser clamps.
f. Non-isolated floor or wall mounted equipment and tanks shall use restraint Type III or V.
g. Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE III shall be located above the component's center of gravity to suitably resist "G" forces specified. Vertically mounted tanks and upblast tubular centrifugal fans, tanks, or similar equipment, may require this additional restraint.
h. A rigid piping system shall not be braced to dissimilar parts of building on two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and roof; solid concrete wall and a metal deck with lightweight concrete fill, pipes, duct, conduit, etc., crossing a building expansion joint.

D. Exclusions From Seismic Restraint Requirements
1. With the exception of life safety components, certain components do not require seismic restraints.
2. The exclusions from seismic restraint requirements DO NOT apply for Life Safety Components as follows:
    a. Piping: Fire protection, fuel oil, gasoline, natural gas, medical gas, compressed air, medical piping or piping that contains hazardous or corrosive materials that is 1-inch nominal diameter and larger.
3. With the exception of life safety components, the following items do not require seismic restraints:
    a. Piping less than 2-1/2-inch diameter.
    b. Clevis or trapeze supported piping suspended by hanger rods less than 12-inch in length (6-inch or less for fire sprinkler piping) with positive attachment to structure.

E. Accommodation Of Differential Seismic Motion
1. 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.

Comply with requirements in Division 22 Sections HVAC and Plumbing for piping flexible connections.

F. Field Quality Control
   1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   2. Perform tests and inspections.
   3. Tests and Inspections:
      a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
      b. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
      c. Obtain Architect's approval before transmitting test loads to structure.
      d. Provide temporary load-spreading members.
      e. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
      f. Test to 90% of rated proof load of device.
      g. Measure isolator restraint clearance.
      h. Measure isolator deflection.
      i. Verify snubber minimum clearances.
      j. If a device fails test, modify installations of same type and retest until satisfactory results are achieved.
   4. Remove and replace malfunctioning units and retest as specified above.
   5. Prepare test and inspection reports.
      a. Upon completion of installation of seismic restraint devices, a certification report prepared by the manufacturer shall be submitted in writing to the contractor indicating that systems are installed properly and in compliance with the specifications. The report must identify those areas that require corrective measures or certify that none exists. Field coordination changes to the originally submitted seismic restraint designs must be clearly defined and detailed in this report.

G. Adjusting
   1. Adjust isolators after piping system is at operating weight.
   2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
   3. Adjust active height of spring isolators.
   4. Adjust restraints to permit free movement of equipment within normal mode of operation.

H. Demonstration
   1. 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."

3.15 IDENTIFICATION OF EQUIPMENT, DUCTWORK, PIPING AND VALVES

A. Equipment Labels: Equipment furnished and installed under this section shall be provided with manufacturers metal labels securely attached to each individual piece of equipment and showing complete and comprehensive performance characteristics, size, model, serial number etc.

B. Name Plate: Install engraved Bakelite nameplates with 1/4-inch high white letters for equipment, switches, controls, room stats, damper motors, indicating zones, etc.

C. Valves shall have tags attached with “S” mounting. Tags shall be at least 1-1/2-inch in diameter. Tags shall be stamped with valve I.D. number (e.g. V-1) and be keyed to valve identification table submitted as part of the Operating Instruction and Maintenance Manuals.

D. Dampers: Mark volume dampers above new or existing ceilings by attaching a bright yellow 12-inch length strip of cloth attached to damper rod. Groove ends of shafts to indicate open and closed position.

E. Piping exposed to view shall have color coded markers as to type of use, service, and direction of flow in accordance with the latest edition of ANSI A 13.1. Locate markers at each valve, at entries to walls, and on 20-ft centers on straight runs of pipe. Provide a flow arrow at each identification marker. Labels or markers shall be made of plastic sheet with pressure sensitive adhesive suitable for the intended application.
   1. Color Coding for Labels and Bands by Hazard Classification:
      a. Safe Materials – Green:
         1) Domestic cold and hot water – green with black letters.
         2) City water – green with white letters
      b. Dangerous Materials – Yellow:
         1) Natural Gas – yellow with black letters
         2) Industrial cold water – yellow with black letters
      c. Fire Protection Equipment – Red:
         1) Fire Sprinkler Piping – red with black letters

F. Nameplate designations shall correspond to the identifications on the “Record Drawings.”

G. Submit to the Architect for approval a list of items to be tagged within two weeks after award of the Contract.

3.16 CLEANING

A. Equipment, piping, ductwork, and related valves and appurtenances, etc. Clean so as to remove rust, scale, plaster or internal obstructions before covering is installed or piping or equipment is painted. No scarring or disfiguring of equipment, piping, etc. will be acceptable before covering or painting is applied.

B. Painted Work: Parts of the work, which are to be painted or which are exposed in the finished work shall be thoroughly cleaned and made ready to receive paint finish.

C. Completion: Upon completion of the work, the Contractor shall remove rubbish, debris and surplus materials, resulting there, from the premises together with test instruments, and equipment and shall leave the site in a neat, clean and acceptable condition as approved by the Architect.

3.17 FLUSHING OF PIPE SYSTEMS

A. Entire pipe systems shall be flushed and cleaned of foreign matter before they are placed in service. The length and number of flushing cycles shall be governed by the complexity of the system, but in no case less than two cycles.

B. Flushing shall be performed using a similar media that is to be carried by the piping system. (Example: Cold water piping – water; etc.)

C. Where pipe strainers have been designed or installed into the piping network, said strainers shall be opened and strainer baskets removed and cleaned several times during the flushing of the system.

D. Chemical Cleaning: For chemical cleaning of closed circuit systems see Section 15500.

3.18 CORROSION PROTECTION

A. Protective coverings for underground steel piping shall be installed in strict accordance with manufacturer's written installation instructions.

B. Testing: Covered pipe shall be tested with high voltage holiday tester in the presence of Architect prior to backfilling all holidays shall be repaired and retested.

C. Plastic sleeves, rubber seals, or other dielectric material shall be used to isolate piping from the building structure where steel piping penetrates concrete floor slabs or walls.

3.19 PAINTING

A. Touch-Up: If the factory finish on any equipment furnished by the Contractor is damaged in shipment or during construction of the building, the equipment shall be refinished by the Contractor to the satisfaction of the Architect.

B. Concealed Materials: Uncoated cast iron or steel that will be concealed or will not be accessible when installations are completed shall be given one heavy coat of black asphalt before concealment.

3.20 ELECTRICAL WORK

A. Furnish electrical interlock wiring diagrams and complete sequences of operation for equipment specified in Division 26 that must interface with other electrical, mechanical, or control equipment. These diagrams shall be submitted to both the mechanical, and electrical engineers for review and coordination.

B. Furnish any additional line or low voltage, mechanical and control system wiring and conduit required over and above that specified in Division 26 as required for complete and functional systems is hereby specified in this Division in complete conformance with the requirements outlined in Division 26 at no additional cost to the Owner.

3.21 PENETRATIONS

A. Duct and pipe penetrations of ceilings shall be sealed air tight with silicone caulking prior to installation of escutcheon rings.

B. Duct and pipe walls or slab penetrations shall be sealed using a UL listed fire rated material.

3.22 PRELIMINARY OPERATIONS

A. Should the Owner require that any portion of the system or equipment be operated prior to the final completion and acceptance of the work, the Contractor shall furnish such operation. The expense thereof will be paid, by the Owner separate and distinct from any money paid on account of the contract.

B. For such preliminary operation, payment shall not be construed as final acceptance of the work of this contract.

3.23 OPERATING INSTRUCTIONS

A. The Contractor shall provide the services of a competent Operating Engineer to supervise the operation of equipment specified herein and to instruct the Owner's operators during a three day operating period. The operating instruction period shall be defined as straight time working hours and shall not include nights and weekends.

B. The Owner shall be notified in writing at least five days before each operating instruction period begins. The Owner must indicate acceptance of the instructional starting time in writing to the Contractor. Upon arrival, the various instructors shall report to the Owner.

3.24 TESTS

A. Tests must be performed and systems approved prior to painting, covering, insulating, furring or concealing piping.

B. Provide test equipment, instrumentations and labor in conjunction with tests.

C. Prior to test, protect or remove control devices, air vent and other items, which are not designed to stand pressure used in test.

D. Accomplish testing of piping in section so as not to leave a portion of pipe or joint untested.

E. Obtain prior approval for test procedure.

F. Responsibility for Damages: Contractor shall pay for costs for repair and restoration of work of other trades damaged by tests or cutting done in connection with tests.

3.25 REPAIRS AND RETEST

A. Refer to related sections.

B. Make other adjustments, repairs and alterations required to meet specified test results.

C. Correct defects disclosed by tests or inspection; replace defective parts.

D. Use only new materials in replacing defective parts; in case of pipe, replace with same length as defective piece.

E. Repeat tests after defects have been corrected and parts replaced, until pronounced satisfactory.

3.26 MECHANICAL SYSTEMS STARTING

A. Start-up all operating systems provided under Division 22.

B. Demonstration of all operating systems provided under Division 22, including, but not limited to:

1. Plumbing Equipment, Appliances and Fixtures including but not limited to Hot Water Heaters.

C. Sequencing: Conduct demonstrations only after systems have been through start-up procedures, systems are complete and operating and operating maintenance data is complete.

D. Verification of Conditions:

1. Existing conditions: Examine preceding work to ensure that systems are operational.
2. Verify with Division 26 contractor:
    a. Temporary services are disconnected and permanent utility services are capable of full loan.
    b. Connections in main switchgear and subpanels are tight.
    c. Necessary tests and check meter readings have been made.
3. Mechanical:
    a. Specified tests on piping systems have been made.
    b. Specified cleaning of piping systems has been completed.
    c. Piping: Conformance with drawings, specifications, and ANSI B31.1. Replace or correct work rejected because of defects or nonconformance with drawings, specifications and ANSI B31.1.
    d. Water treatment has been completed.
    e. Operational and performance tests have been made.
    f. 24 hours and recheck.
    g. Verify plumbing fixtures operate.
    h. Verify integrity of wiring.
    i. Verify sensors are provided and in correct location.
    j. Verify range of each device and check software is compatible sensor calibration.
    k. Test voltage on each input and output.
    l. Test start/stop points to verify correct equipment operates.
    m. Check sensor calibration.

E. Submit testing plan for review prior to testing. Indicate order of procedure, list items will be tested and order of testing show where controllers and devices are located.

F. Provide report indicating equipment operated properly and as per sequence of operation.

3.27 START-UP TESTING

A. Notification: Notify owner at least two days in advance of start-up of mechanical systems.

B. Start-up and Testing: Conduct start-up and start-up testing in presence of owners. See applicable Division 22 Sections for specific requirements.

C. Lubrication: Field check and field lubricate equipment requiring lubrication prior to initial operation.

D. Code Authorities: Complete tests required by code authorities including smoke detection, fire protection and health codes.

E. Control Systems: Ensure control systems are fully operational in manual and automatic modes.

F. Test equipment before and after installation as applicable where necessary to determine compliance with specifications.

G. Start-up and Testing: Conduct start-up and start-up testing in presence of Owner. See applicable Division 22 Sections for specific requirements.
1. Periodically clean various strainers during initial operation until no further accumulation of foreign materials occurs. Exercise care so minimum loss of water occurs when strainers are cleaned.
2. Adjust safety and automatic control instruments as necessary to place them in proper operation and sequence.

H. Field Tests: Subject the work of Division 22 to necessary field tests after installation and before acceptance.
   1. Make proper corrections, repairs and replacements should tests reveal evidence of malfunction. Repeat tests until proper and successful operation is achieved.
   2. If final control settings and adjustments cannot be properly made to performance tests because of time of year, make field tests as first seasonal use of systems following completion of project.

I. Cleaning and Adjusting: After test runs have been completed and systems have been demonstrated to be satisfactory and ready for permanent operation. Clean permanent pipeline strainers properly adjust valve and pump packings, secure drive guards in place, check lubrication and replenish if required.

J. Protection: If systems are not to continue in sue following start-up procedures, take steps to ensure against accidental operation or operation by unauthorized personnel.

K. Instruct Owner's representatives once on proper operation and maintenance of mechanical systems. Include seasonal concerns and operations.

L. Systems: Mechanical systems provided under Division 22. See applicable Division 23 Sections for additional requirements.

M. Contractor's Representatives: Have thorough knowledge of particular installation and system.

N. Manufacturer's Representatives: Have thorough understanding of each particular equipment and system.

O. Scheduling: Arrange and schedule demonstration times with Owner.

P. Location: Conduct demonstrations at Project including tours of systems.

Q. Operating and Maintenance Date: Arrange for data to be at demonstrations. Include review of data at demonstrations.

3.28 COMPLETION DATE AND TESTING OF MECHANICAL SYSTEMS:

A. Final Acceptance Tests shall be sufficiently in advance of the contract completion date to permit the execution before that expiration of the contract of any adjustments and/or alterations, which the final acceptance tests indicate as necessary for the proper functioning of equipment.
   1. Modifications shall be completed within the number of days allotted for completion of the contract. Retests shall not relieve the Contractor of completion date responsibility.

B. Starting and Operation: Before starting or operating equipment of systems, make through check to determine that the systems have been flushed and cleaned as required and equipment has been properly installed, lubricated and serviced. Notify owner at least three days in advance of starting these tests.

3.29 FINAL REVIEW

A. Date and Time: At a time designated by the Owner, the entire system shall be reviewed by the Architect. The Contractor shall be present at this review.

B. System Operation: The system shall be operating properly within water and air volumes balanced and all temperature controls adjusted. Labels shall be removed from the plumbing

fixtures, and the fixtures shall be cleaned and in operating condition. Air and Water Balance Report shall be submitted to the Owner.

C. Documentation: Certificates and documents required herein shall be in order and presented to the Architect at least two weeks prior to the review.

D. Changes and Corrections: After the review, changes or corrections noted by the Architect as necessary for the work to comply with these specifications and the drawings shall be accomplished without delay in order to secure final acceptance to the work.

END OF SECTION

SECTION 22 05 11

PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work listed or required by this section of the specifications is not intended to limit or establish the extent of the Plumbing work. The General Contractor shall be responsible for determining the extent of the Plumbing work to be done under a subcontract.

1.2 DESCRIPTION

A. Work Included: The work includes the furnishing of labor, materials, appliances and tools necessary for the installation, in complete working order, of plumbing systems as herein specified and as indicated on the drawings. The item of work shall include, but not be limited to, the following principal items:
   1. Plumbing fixtures and equipment included in plumbing schedule or as indicated on the drawings.
   2. Soil, waste and vent piping system.
   3. Potable hot and cold water, tempered water and piping systems.
   4. Non-potable hot and cold water piping systems.
   5. Domestic hot water heater and circulating pump systems.
   6. Natural gas piping system.
   7. Sleeves, hangers and seismic bracing for piping systems.
   8. Insulation of piping.
   9. Testing.
   10. Excavation and backfill.
   11. Rough-in and connection of equipment and/or fixtures furnished under sections of this specification other than Section 22 05 00 including plumbing utilities for equipment and appliances provided by Kitchen Consultant.
   12. Other miscellaneous items and equipment required for a complete installation.
   13. Seismic restraints for pipe.
   14. Rough-in and final gas and water connections to mechanical equipment as required.

B. Other work herein specified and shown on the accompanying drawings including addenda, change order and approved shop drawings.

C. The Contractor shall furnish other tradesmen with drawings and directions necessary to enable them to properly construct their work so that the systems shall be properly interconnected.

D. The Contractor shall be responsible for the correctness of his drawings and instructions and make, at his expense, any necessary changes in the completed work of other trades made necessary by errors in his drawings or instructions.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Work designated on drawings to be installed or performed by other sections of the specifications including Section 23 05 00: Common Work Results for Mechanical.

B. Finish painting of equipment and piping shall be under Division 9 Painting Section, except as noted otherwise.

C. Equipment foundations, curbs, or equipment pads as provided under the Concrete Section or Structural Steel Section. Coordinate exact foundation sizes and elevations, and anchor bolt sizes and locations.

1.4 EQUIPMENT RESTRICTIONS

A. Refer to Sections 22 05 00.

1.5 SUBMITTALS

A. In addition to the requirements of Section 22 05 00, submittal brochures shall include the following items:
   1. Piping Materials:
      a. Waste and Vent
      b. Potable Hot and Cold Water
      c. Non-potable Cold Water
      d. Natural Gas
   2. Piping Accessories:
      a. Hangers
      b. Dielectric Couplers
      c. Hanger Supports
      d. Insulation
      e. Hanger Brackets
      f. Water Hammer Arrestors
      g. Seismic Restraints
      h. Piping Identification
   3. Valves
      a. Gate Valves
      b. Check Valves
      c. Ball Valves
   4. Access Panels

B. Contractor shall coordinate and provide shop drawings of the following:
   1. Dimension drawings for concrete pad, curb and equipment foundations (1/4” scale minimum) including bolt sizes and locations.
   2. Steel fabrication drawings for equipment and pipe supports attachments (1/8” scale).
   3. Control Wiring Diagrams.

PART 2 - PRODUCTS

2.1 PIPING SYSTEMS

A. Sewer, Waste & Vent Piping
   1. Hub-less cast iron pipe and fittings conforming to the standards contained in the CISPI 301, ASTM A888, and ASTM A74. Pipe and fittings shall be marked with the collective trademark of the CISPI.
   2. Stainless steel compression couplings shall conform to the standards contained in CISPI 310. Joints for hub-less pipe and fittings shall conform to the requirements of FM1680 and shall be heavy-duty type 304 stainless steel shielded couplings. Smooth shielded couplings shall have a shield with a minimum thickness of 24 gauge and corrugated shields with thickness of 28-gage.
   3. Manufacturers:
      a. A, B, & I Foundry
      b. Tyler Pipe
      c. Charlotte Pipe
   4. Approved Joints Manufacturer: Husky SD 4000 or Clamp-All 125.

B. Potable and Non-Potable Cold Water, Tempered Water and Hot Water (Above Grade)
   1. ASTM B88, Type “L” seamless hard drawn copper tubing with ASTM B16.22 wrot copper fittings. Joints shall be soldered with lead-free, tin-zinc alloy solder. Flanges: bronze solder joint, ANSI 150 lb. Hot water piping shall be insulated as required.

C. Potable and Non-Potable Cold Water Piping (Below Grade)
   1. ASTM B88, Type “K” seamless hard drawn copper tubing with ASTM B16.22 wrot copper fittings. Joints shall be brazed with Sil Fos 7.

D. Natural Gas Piping, above Grade:
   1. Pipe:
      a. 2-inch and smaller: ASTM A-53, Schedule 40, black steel.
      b. 2-1/2 to 6-inch ASTM A-53, Schedule 40, black steel, seamless.
      c. 8 to 12-inch: ASTM A-53, Schedule 20, black steel, seamless.
   2. Fitting:
      a. 2-inch and smaller: Screwed: malleable iron, black, 150-psig unions: Malleable iron, black, ground joint, 250-psig, Grinnel No. 554.
      b. 2-1/2-inch and larger: Welded only, 3 pass, butt welded fittings.

2.2 VALVES

A. Provide valves required for draining, servicing, and full control of piping and equipment.

B. Gate Valve
   1. Manufacturer based upon Stockham or Crane.
   2. Provide solid wedge disc with non-rising stem, repackable under full operating pressure when wide open.
   3. Provide valves designed for 125-psig stem and 200-psig non-shock water working pressures.
   4. Size 2-inch and smaller:
      a. Bronze body, bonnet and disc conforming to ASTM B62. Stems shall be copper silicon alloy, ASTM B371.
         1) Stockham

a) Figure B-104, solder joint ends
b) Figure B-103, NPT threaded ends.

2) Crane
a) Figure 1701, solder joint ends
b) Figure 438, NPT threaded ends

C. Ball Valve
1. Manufacturer based upon Stockham or Crane
2. Provide valves designed for 125-psig steam and 400-psig non-shock water.
3. Size 2-inch and smaller
a. Two-piece bronze body full port with brass with hard chrome plated ball, PTFE seats and stem seals, blowout-proof stem with lever handle.
1) Stockham
a) Figure No. S-214 BR-T-S, solder cup ends
b) Figure S-214 BR-T-T, NPT threaded ends
2) Crane
a) Figure 9323-B, solder joint ends
b) Figure 9303-B, NPT threaded ends

D. Swing Check Valve
1. Manufacturer based upon Stockham or Crane.
2. Provide valves designed for 125-psig steam and 200-psig non-shock water.
3. Size 3-inch and smaller:
a. Bronze body, horizontal swing, Y-pattern with 45º seat regrindable type, with renewable seat and disc.
1) Stockham
a) Figure S-321 solder joint ends
b) Figure B-321, NPT thread ends
2) Crane
a) Figure 1342, solder joint ends
b) Figure 137, NPT threaded ends.

E. Pressure Reducing Valve
1. Manufacturer based upon Wilkins “500 YSBR Series”. Equal products by Watts Regulator or Cla-Val may be submitted for approval.
2. Bronze body and bell housing, nylon reinforced Buna-N diaphragm and renewable stainless steel seat.

F. Backflow Prevention
1. Manufacturer based upon Wilkins. Equal products by Watts Regulator or Cla-Val may be submitted for approval.
2. Reduced Pressure Principle Type: Cast Iron Body with spring loaded, diaphragm assisted main check valve, a spring loaded second check valve and a spring loaded diaphragm actuated differential pressure relief valve, body rated for 175-psig working pressure complete with two full port resilient wedge gate valves and four resilient seated ball valve test cocks. Stainless steel and bronze corrosion resistant internal parts and replaceable seats.
3. Double Check Type: Cast Iron body with two independently acting check valves, two gate valves, four test cocks. Body rated for 150-psig working pressure. Stainless steel and bronze corrosion resistant internal parts and replacement seats.
4. Arrange for and pay fees for testing and certification of backflow prevention devices by a firm or agency approved by the Owner’s Representative.

2.3 INSULATION

A. Insulation thickness for pipe, fittings, equipment, and valves shall conform to Title 24, Part 6 as a minimum. Use thickness specified, if greater than Title 24, Part 6 requirements. Insulation to have a flame spread of not more than 25 and a smoke density not exceeding 50 when tested as a composite.

B. Pipe
   1. Manufacturer based upon Johns Manville. Equal products by Schuller or Owens Corning may be submitted for approval.
   2. Micro-Lok
      a. Rigid molded fiber glass pipe insulation meeting ASTM C 547.
      b. Chilled water thermal conductivity ("k") value of 0.23-Btu*in/(hr*ft^2*°F) at 75°F.
      c. Heating hot water thermal conductivity ("k") value of 0.29-Btu*in/(hr*ft^2*°F) at 200°F.
      d. Maximum service temperature of 850°F.
      e. Provide vapor retarder jacket AP-T PLUS white kraft paper paper reinforced with glass fiber yarn and bonded to aluminum foil, secures with self sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples or vapor barrier mastic as needed.
   3. Thermo-12 Gold (high temperature applications)
      a. Rigid molded hydrous calcium silicate meeting ASTM C 533, Type I
      b. Insulation shall be asbestos free coded throughout material thickness and maintained throughout temperature range
      c. Heating hot water thermal conductivity ("k") value of 0.45-Btu*in/(hr*ft^2*°F) at 300°F.
      d. Maximum service temperature of 1200°F.
      e. Compressive Strength (block): Minimum of 200-psig to produce 5% compression at 1-1/2-inch thickness.
      f. Noncombustible as per ASTM E136 test.
   4. Zeston 2000 PVC
      a. One piece, field applied pipe fitting cover and jacketing material, gloss white, UV-resistant.

C. Equipment
   1. Manufacturer based upon Johns Manville. Equal products by Schuller or Owens Corning may be submitted for approval.
   2. 812 Series Spin-Glas
      a. Flexible equipment insulation meeting ASTM C 533, Type III.
      b. Thermal conductivity ("k") value of 0.24-Btu*in/(hr*ft^2*°F) at 75°F.
      c. Maximum service temperature of 450°F.
      d. Density shall equal 1.50-lb / ft^3.
      e. Provide aluminum foil reinforced with fiber glass yarn and laminated with fire-resistive adhesive to kraft paper (FSK Reinforced Foil and Paper). Secure with UL listed pressure sensitive tape and / or outward clinch expanding staples and vapor barrier mastic.
   3. 814 Series Spin-Glas
      a. Rigid equipment insulation meeting ASTM C 612, Type IA and IB.
      b. Thermal conductivity ("k") value of 0.23-Btu*in/(hr*ft^2*°F) at 75°F.
      c. Maximum service temperature of 450°F.
      d. Density shall equal 3-lb / ft^3.
      e. Provide aluminum foil reinforced with fiber glass yarn and laminated with fire-resistive adhesive to kraft paper (FSK Reinforced Foil and Paper). Secure with UL listed pressure sensitive tape and / or outward clinch expanding staples and vapor barrier mastic.

4. Thermo-12 Gold
    a. Rigid molded hydrous calcium silicate meeting ASTM C 533, Type I.
    b. Insulation shall be asbestos free coded throughout material thickness and maintained throughout temperature range.
    c. Heating hot water thermal conductivity (“k”) value of 0.45-Btu*in/(hr*ft^2*°F) at 300°F.
    d. Maximum service temperature of 1200°F.
    e. Compressive Strength (block): Minimum of 200-psig to produce 5% compression at 1-1/2-inch thickness.
    f. Noncombustible as per ASTM E136 test.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General
1. Inspect the architectural, structural, fire protection, special systems and HVAC drawings and specifications to become familiar with the type of building construction and to coordinate with the work of others.
2. Apparatus, fixtures, devices and appliances which require pipe connections shall be so equipped and each such pipe connection shall be valved or trapped, or provided with special apparatus as indicated on the drawings or elsewhere specified. Where such connections are not indicated on the drawings or specified, they shall be made in the usual manner recommended by the manufacturer of each such equipment.

B. Piping:
1. Install in a manner that permits expansion and contraction caused by changes in water temperature and pressure. Provide additional supports as required. Run pipes straight and true, parallel to or at right angles to the building walls. Springing or forcing piping into place will not be permitted.
2. Reduced fittings shall be used in lieu of bushings. Close nipples will not be permitted.
3. Pipelines shall be installed in the locations and of the sizes shown on the drawings or specified herein and of the material and workmanship herein specified and shall be free from all stain, tool marks or other foreign substances.
4. Exposed piping in the building shall be installed parallel to or at right angles to the building walls. Pipelines shall be installed free from traps and air pockets and true to line and grade. Horizontal lines shall be installed as close to the building construction as possible so as to leave the greatest possible head room under them.
5. The only filler that may be used in making up screw joints in pipe lines shall be an approved graphite paste or Teflon tape.
6. Copper tube water lines shall be fitted with drop ear elbows securely anchored to the building framing at each fixture supply stub-out.
7. Where pipes of two dissimilar metals are joined, “Mallory” dielectric couplings or approved equal shall be installed.
8. Saw cut or core drill existing slabs or walls to install pipes, equipment or fixtures.
9. Where valves are not accessible from utility or furred spaces, the contractor shall furnish and install “Access Panels” as specified hereinafter. The locations of access panels shall be coordinated with Architect.
10. Where screw end valves are used in threaded pipelines there shall be a union installed in the pipe as close to the valve as possible. At soldered pipelines an I.P.S. to copper adaptor shall be installed on both sides of valve screw end.
11. Valves of pipe lines shall be tagged with the valve discs or nameplates as specified hereinafter, except where the use is obvious or where the apparatus controlled is visible form the valve.

12. Valves other than relief valves and air vent valves shall be the same size as the pipe lines in which they are installed. Valves shall be packed with an approved brand or graphite valve stem packing.

C. Fixtures and Equipment:
   1. Install in strict accordance with manufacturer's written installation instructions and recommendations. Fixtures shall be roughed in only from fixture manufacturer's certified "Rough-In" Measurement Drawings" which shall be submitted to the Contracting Officer Representative for approval.

D. Backflow protection devices of code approved type and shall be provided and installed where required by code.

3.2 INSULATION

A. Verify that surfaces are clean, dry and free of foreign material.

B. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.

C. Continue insulation vapor through penetrations except where prohibited by code.

D. Piping Insulation:
   1. Locate insulation and cover seams in least visible locations.
   2. Neatly finish insulation at supports, protrusions and interruptions.
   3. Provide insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature with vapor retardant jackets with self-sealing laps. Insulate complete system.
   4. For insulated pipes conveying fluids above ambient temperature, secure jackets with self-sealing lap or outward clinched, expanded staples. Bevel and seal ends of insulation at equipment, flanges and unions.
   5. Provide insert between support shield and piping on piping 1-1/2-inch diameter or larger. Fabricate of Johns Manville Thermo-12 or other heavy density insulating material suitable for temperature. Insulation inserts shall not be less than the following lengths:
      a. 1-1/2 to 2-1/2-inch pipe size 10-inch long
      b. 3 to 6-inch pipe size 12-inch long
   6. For pipe exposed in mechanical equipment rooms or in finished spaces below 10-foot above finished floor, finish with Johns Manville Zeston 2000 PVC jacket and fitting covers or aluminum jacket.
   7. For exterior applications, provide weather protection jacket or coating. Insulated pipe, fittings, joints and valves shall be covered with Johns Manville Zeston 2000 PVC or aluminum jacket. Jacket seams shall be located on bottom side of horizontal piping.

3.3 SEISMIC REQUIREMENTS

A. Equipment and piping shall be provided with seismic restraint devices to limit movement. Refer to Seismic Bracing Notes on P-0.1.

3.4 PIPE CLEANING AND DISINFECTION FOR POTABLE WATER PIPING

A. Pipe cleaning and disinfection applied to hot and cold potable water systems and shall be performed after all pipes, valves, fixtures, and other components of the systems are installed, tested and ready for operation.

B. Potable water piping shall be thoroughly flushed with clean potable water prior to disinfection, to remove dirt and other contaminants. Screens to faucets shall be removed before flushing and reinstalled after completion of disinfection.

C. Disinfection shall be done using either chlorine gas or liquid chlorine. Calcium or sodium hypochlorite may be used as approved in AWWA C601 procedures.

D. A service valve shall be provided and located at the water service entrance. The disinfecting agent shall be injected into the system from this valve only.

E. The disinfecting agent shall be injected by a proportioning pump or device through the service cock slowly and continuously at an even rate. During disinfection, backflow of disinfecting agent into main water supply is not permitted.

F. Sectional valves must be operated during disinfection. Outlets must be fully opened at least twice during injection and the residual checked with orthotolin solution.

G. When the chlorine residual concentration, calculated on the volume of water the piping will contain, indicates not less than 50-ppm at outlets, then valves must be closed and secured.

H. The residual chlorine shall be retained in the piping systems for a period of not less than 24 hours.

I. After the retention, the residual shall be not less than 4-ppm. If less, then the process shall be repeated as described above.

J. If satisfactory, then fixtures shall be flushed with clean potable water until residual chlorine by orthotolin tests shall be not greater than the incoming water supply (this may be zero).

K. Work and certification of performance shall be performed by approved applicators or qualified personnel with chemical and laboratory experience. Certification of performance shall indicate:
   1. Name and location of the job and date when disinfection was performed.
   2. Material used for disinfection.
   3. Retention period of disinfectant in piping system.
   4. PPM chlorine during retention.
   5. PPM chlorine after flushing.
   6. Statement that disinfection was performed as specified.
   7. Signature and address of company/ person performing disinfection.

L. Upon completion of final flushing (after retention period), the Contractor shall obtain one water sample from hot water system and one form the cold water system and submit samples to a State approved laboratory. Results from laboratory shall be provided to Contracting Officer Representative Engineer and shall indicate:
   1. Name and address of approved laboratory testing the samples.
   2. Name and location of job and date the samples were obtained.
   3. The coliform organism count. An acceptable test shall show absence of coliform organisms.

M. If analysis does not satisfy the above minimum requirements, the disinfection procedure must be repeated.

N. Before acceptance of the systems, the Contractor shall submit to the Contracting Officer Representative for his or her review, three copies of Laboratory Report and three copies of Certification of Performance as specified above.

O. Under no circumstances shall the Contractor permit the use of any portion of potable water systems until properly disinfected, flushed and certified.

3.5 TESTS

A. Drainage piping shall be tested and proved tight under 10-foot of water pressure prior to replacing ceilings.

B. Water piping and pumped drain or forced main piping shall be purged of air and tested and proved tight under 125-psig hydrostatic pressure for a period of not less than two hours.

3.6 CLEANING

A. Equipment, piping, etc., shall be thoroughly cleaned so as to remove rust, scale, plaster, or internal obstructions before a covering is installed or piping or equipment is painted. no scarring or disfiguring of equipment, piping, etc. will be acceptable before covering or painting is applied.

B. Parts of the work which are to be painted or which are exposed in the finished work shall be thoroughly cleaned and made ready to receive paint finish.

C. The exposed parts of equipment shall be cleaned, oil and grease removed, and the bright parts left clean and polished.

D. Upon completion of the work, remove rubbish, debris and surplus materials, resulting there from, the premises together with his instruments, and equipment and shall leave the site in a neat, clean and acceptable condition as approved by the Architect.

3.7 PRELIMINARY OPERATIONS

A. Should the Owner require that a portion of the systems or equipment be operated prior to the final completion and acceptance of the work, the Contractor shall furnish such operation. The expense thereof will be paid by the Owner, separate and distinct from money paid on account of the contract.

B. Such preliminary operation or testing, payment shall not be construed as final acceptance of the work of this contract.

3.8 EXCAVATION AND BACKFILL

A. Comply with the requirements for trenching, backfilling and compaction as specified in Division 2.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements of Divisions 0 and 1 apply to work of this section.

1.2 RELATED SECTIONS

A. This section applies to all sections of Division 23, except as may be otherwise modified in each section.

1.3 FEES, PERMITS AND PAYMENTS

A. Fees, Permits and Payments: Contractor shall secure permits and inspections and pay full cost of same.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Work designated on drawing or specifications to be installed or performed by other sections of the inspections.

B. Finish painting: Equipment furnished shall be factory finished. If the factory finish is damaged during shipment, installation, etc., it shall be repainted by the Contractor subject to the Architect's approval.

C. Electrical connections for motors, line voltage wiring and conduit and low voltage wiring and conduit.

D. Individual motor controllers except when furnished as integral parts of packaged equipment.

1.5 EQUIPMENT RESTRICTIONS

A. The proprietary name, and/or model indicated on the drawings, or the first listed for a category in the specifications is the make and/or model used as the basis for design. Bids shall be based on the use of the products of the selected manufacturers. Substitutions will be considered as outlined in General Conditions and Division 1; Section, "Substitutions." Other acceptable manufacturers are named in these specifications.

B. Choice of Equipment: Equipment has been chosen, which will properly fit into the physical spaces provided and indicated, allowing ample room for access, serving, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with the code requirements and the requirements of the local inspection Department. Physical dimensions and arrangements of equipment to be installed shall be subject to the Owner's approval. Submit shop drawings of equipment layout for approval where equipment space does not comply with drawings. Changes in piping, motors, wiring, controls, structural or installation procedures required by the substituted product or equipment shall be made at no additional cost to the Owner, and with no reduction in scope.

C. Space Requirements:

1. In the preparation of drawings, a reasonable effort has been made to include equipment manufacturer's recommendations. Since space requirements and equipment arrangement vary according to manufacturer, the responsibility for initial access and proper fit rests with the Contractor. The final arrangement of the equipment and service connections shall allow the unit to be serviced. This shall include space to pull motors, filters, coils, tubes, etc. Make changes in piping and ductwork to suit actual installed equipment without further instructions or additional cost.
2. If the installation of the particular product or equipment, the Contractor has submitted, requires changes in material or size from that required in the contract drawings and specifications, such changes shall be submitted as shop drawings.
3. Contractor shall be aware that some equipment in the mechanical room must be in place before walls and/or roof is installed and shall schedule the installation of equipment accordingly.
4. Contractor shall pay the costs of design (3.0 x direct payroll) and installation of changes resulting from substitution of alternate products. Acceptance of alternate products by Architect does not change this requirement.

1.6 QUALITY ASSURANCE

A. Installer's Qualifications:

1. For the actual fabrication, installation, and testing of work, use only thoroughly trained and experienced workmen completely familiar with the items required and the manufacturers' current recommended methods of installation.
2. In acceptance of rejection of the finished installation, no allowance will be made for lack of skill on the part of the installers.

B. Certificates: Execute on behalf of the Owner and deliver to the Architect manufacturers' warranty certificates and instructions, etc. required to assure that the manufacturers' warranties are properly documented and in full effect for the warranty period.

1.7 CODES, ORDINANCES, REGULATIONS AND DEFINITIONS

A. Work and materials shall be in full accordance with the 2013 rules and regulations of the following Agencies and Codes, the Safety Orders of the Division of Industrial Safety; the California Mechanical Code; the California Plumbing Code; California Fire Code; the California Building Code; California Energy Conservation Code; city ordinances and other applicable laws or regulations.

B. Nothing in the drawings or specifications is to be constructed to permit work not conforming to these codes. Drawings and specifications shall take precedence when work and materials called for exceed code requirements.

C. References to Code Specifications shall mean editions in effect at date of proposals.

D. Reference to technical societies, trade organizations, governmental agencies are made in Mechanical Sections in accordance with the following abbreviations:

AABC	*Associated Air Balance Council National Standards for Field Measurement and Instrumentation, Total System Balance*
AMCA	*Air Moving and Conditioning Association*
ANSI	*American National Standards Institute*
ARI	*Air Conditioning and Refrigeration Institute*

ASHRAE	*American Society of Heating, Refrigerating, and Air Conditioning Engineers*
ASTM	*American Society of Testing and Materials*
ETL	*Electrical Testing Laboratory*
ICC-ES	*International Code Council Evaluation Service*
IRI	*Industrial Risk Insurers*
ISO	*Insurance Service Organization*
NEBB	*National Environmental Balancing Bureau Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems*
NEC	*National Electrical Code*
NFC	*National Fire Codes*
NFPA	*National Fire Protection Association*
NRCA	*National Roofing Contractor's Association*
OSHPD	*Office of Statewide Health Planning and Development for the State of California*
SMACNA	*Sheet Metal and Air Conditioning*
UL	*Underwriter's Laboratories, Inc.*

E. Definitions:

APPROVED	*As approved by Owner's Representative.*
ARCHITECT / ENGINEER	*The Architect or Engineer of record for this project. The Architect or Engineer is the Owner's representative regarding preparation, revisions and interpretation of the contract documents.*
AS DIRECTED	*As directed by the Owner's Representative.*
AS REQUIRED	*As required by applicable Code requirements; by good business practice; by the conditions prevailing; by the Contract Documents; by Owner, or by Owner's Representative.*
AS SELECTED	*As selected by Owner's Representative.*
BY OTHERS	*Work on this Project that is outside the Scope of Work to be performed by the Contractor under this Contract, but that will be performed by Owner, other Contractors or other means.*
CERTIFIED TEST REPORTS	*Test Reports signed by an authorized official stating that tests were performed in accordance with the test method specified that the results reported are accurate, and that items tested either meet or fail to meet the stated minimum requirements.*

CERTIFIED INSPECTION REPORTS	*Reports signed by approved Inspectors attesting that the items inspected meet the Specification requirements other than any exceptions included in the report.*
CONCEALED	*Embedded in masonry, concrete or other construction, installed within furred spaces, or in enclosures.*
EQUAL	*The Contract documents are based upon the manufacturer and model number indicated on the drawings or specifications. Bidder may propose alternative product but will be considered only if the bidder has submitted a base Bid, which is in accordance with the specified product. Alternate proposal shall include complete technical data and itemized price adjustments. Bidder shall assume the responsibility that the alternate product meets the physical, mechanical, electrical, structural, acoustical and architectural requirements of the specified product. Acceptance of an alternate product does not entitle the Contractor to a Change Order to modify architectural, structural, mechanical, electrical, control or any other systems necessary to accommodate the alternate product. The Owner or his representative may reject alternate products.*
EXPOSED	*Not installed underground or not concealed as defined above.*
FIELD TESTS	*Tests or analysis made at, or in the vicinity of the job site in connection with the actual construction.*
FURNISH	*Supply and deliver to the Project site only, not install (unless required to be installed elsewhere in the Contract Documents). Product must be delivered ready for installation and in operable condition.*
INSTALL	*Install (services or labor) only, not furnish (unless required to be furnished elsewhere in the Contract Documents). Install means to place in final position, complete, anchored, connected and ready to operate.*
LIFE SAFETY SYSTEMS	*Systems involved with fire protection: including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers, and smoke exhaust.* *Systems involved with and/or connected to emergency power supply: including generators, transfer switches, transformers, and circuits to fire protection, smoke evacuation, and emergency lighting systems.* *Medical and life support systems.* *Fresh air and relief systems on emergency smoke*

	control sequence.
MAIN	*The principal artery of a system of continuous piping or ductwork, to which branches may be connected.*
MANUFACTURER'S DIRECTIONS, INSTRUCTIONS, RECOMMENDATIONS, SPECIFICATIONS	*Manufacturer's written directions, instructions, recommendations, specifications.*
PRODUCT	*Materials, systems, equipment and fixtures.*
MANUFACTURER'S CERTIFICATE CONFORMANCE	*A certificate signed by an authorized manufacturer's official attesting that the material or equipment delivered meets the specification requirements. Manufacturer's representative certificate is not acceptable.*
MUST; SHALL; TO; WILL	*When used as a directive to the Contractor, these items indicate a mandatory action.*
NECESSARY	*Essential to completion of work.*
OWNER-FURNISHED, CONTRACTOR-INSTALLED	*To be furnished by the Owner at its cost and installed by the Contractor as part of the work.*
PROVIDE	*Shall include "Furnish and install" which means supply, fabricate, deliver, place and connect, complete in place, ready for operational use. When neither furnish, install or provide is stated, "provide" is implied.*
REMOVE	*To remove item completely including attachments, frames, anchors, fittings, bases, pipes, conduits and supports, capping behind finished surfaces and repairing floors, bases and walls to match color and texture and be smooth with existing adjacent surfaces.*
SHOWN	*As indicated on the Drawings.*
SPECIFIED	*As written in the Contract Documents.*
SUBMIT	*Submit to Owner's Representative.*
TESTING LABORATORY	*A person or organization whose functions include testing, analyzing or inspecting products and/or evaluating the designs or specifications of such products according to the requirements of applicable standards.*
WORK	*Work of the Contractor or Subcontractor includes labor or materials (including, without limitation, without equipment and appliance) or both, incorporated in, or to be incorporated in the construction covered by the complete Contract.*

1.8 SEISMIC RESTRAINT

A. Design, furnish, and install attachment devices, anchor bolts, and seismic restraints that are required for seismic compliance for all equipment, apparatus, piping, conduit and raceways, ductwork, and other components of the specified systems required by reference codes and standards.

B. Provide seismic restraint types as described. If the item to be restrained is not listed, select appropriate restraint and submit for approval.

C. Provide seismic bracing for mechanical, plumbing, and fire protection systems.

D. Performance Requirements
   1. Isolate motor driven mechanical equipment, unless otherwise noted, from the building structure, and from the systems which they serve, to prevent equipment vibrations from being transmitted to the structure.
   2. Consider equipment weight distribution to provide uniform deflections.
   3. For equipment with variable speed capability, select vibration isolation devices based on the lowest speed.
   4. Seismic Restraints Requirements
      a. For each seismic restraint, provide certified calculations to verify adequacy to meet the following design requirements:
      b. Ability to accommodate relative seismic displacements of supported item between points of support.
      c. Ability to accommodate the required seismic forces.
      d. For each respective set of anchor bolts provide calculations to verify adequacy to meet combined seismic-induced sheer and tension forces.
      e. For each weld between structure and item subject to seismic force, provide calculations to verify adequacy.
      f. Restraints shall maintain the restrained item in a captive position without short circuiting the vibration isolation.

1.9 SUBMITTALS

A. General: Refer to Division 1.

B. Project Drawings:
   1. The drawings are diagrammatic and indicate the general layout of the equipment.
   2. The exact location shall be field determined, after shop drawing review for the installation in available space at the job site.

C. Equipment Lists and Equipment Brochures and Shop Drawings.
   1. Copies: Submit six copies of data as specified hereafter.
   2. Items of material and equipment required by this Division shall be reviewed by the Architect prior to the start of work. The Contractor shall submit items requiring such review, allowing ample time for the checking and processing, and shall assume responsibility for delays incurred due to the rejected items. Rejected items shall be resubmitted as specified only. Submittal information covering items shall be neatly bound together into booklets, each booklet containing individual items specified. Separate submittals of individual items are not allowed. Each submittal item shall be identified with the governing specification section, paragraph, subparagraph, or reference drawings, as applicable.
   3. Equipment Lists: Provide name of manufacturer, brand name, and catalog number of each item. Submit complete submittals, at one time, having items arranged in numerical sequence with each item identified by section and article of the specifications. Listing

items “as specified” without both name and model or type designation is not acceptable, except pipe and fitting not specified by brand names may be listed “as specified” without manufacturer’s name, provided proposed materials comply with specification requirements.

4. Material Brochures: Provide copies of complete description, information and performance data covering materials and equipment, which are specified. Brochures submitted to the Architect shall be published by the manufacturers and shall contain complete and detailed engineering and dimensional information. Brochures not compiled in the following manner shall be returned for re-submittal. Brochures submitted shall contain only information relevant to the particular equipment or materials to be furnished. The Contractor shall not submit catalogs, which describe several different items other than those items to be used unless all irrelevant information is marked out, or unless relevant information is clearly marked. Brochures from each manufacturer shall be identified.
5. Shop Drawings:
   a. Refer to Divisions 0 and 1.
   b. Provide additional data as specified in Governing Specification Section.
6. Seismic Restraint
   a. Shop Drawings
      1) Where walls and slabs are used as seismic restraint locations, provide details of acceptable methods for restraint of equipment, ducts, conduit and pipe shall be included, with supporting certified calculations.
      2) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
      3) A copy of the coordination or contract drawings shall be marked-up with the specific locations and types of restraints shown for pipe, duct, and equipment. Rod bracing and assigned load at each restraint location shall be clearly delineated. Each drawing shall be signed by the same engineer performing the seismic calculations noted below.
      4) For ceiling suspended equipment, provide minimum and maximum installation angle allowed for restraint system, as well as braced and un-braced rod lengths at each allowable installation condition.
   b. Seismic Certification and Analysis
      1) Seismic restraint calculations shall be provided for connections of equipment to the structure. Performance of products (such as: strut, cable, anchors, clips, etc.) associated with restraints shall be supported with manufacturer’s data sheets or certified calculations. Seismic calculation shall be certified by a Professional Structural or Civil Engineer registered in the State of the project.
      2) Seismic restraint calculations shall be based on the acceleration criteria required by local codes. Note: For roof-mounted equipment, both the seismic acceleration and wind loads shall be calculated; the highest load shall be utilized for the design of the restraints and isolators.
      3) Calculations to support seismic restraints designs shall be stamped by a professional engineer who is registered in the state where the work is being performed, with at least five years of seismic design experience.
      4) Table elevations refer to the structural point of attachment of the equipment support system (i.e., use floor slab for floor supported equipment and the elevation of the slab above for suspended equipment).
      5) Analysis shall indicate calculated dead loads, derived loads, and materials utilized for connections to equipment and structure. Analysis shall detail anchoring methods, bolt diameter, embedment and/or weld length.

   c. Product Data: For the following:
      1) Include rated load, rated deflection, and overload capacity for each vibration isolation device.

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 OSHPD or an agency acceptable to authorities having jurisdiction.
    b) Annotate to indicate application of each product submitted and compliance with requirements.
3) Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

d. Delegated-Design Submittal: For 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 with at least five years of seismic design experience responsible for their preparation.
1) Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic and wind forces required to select vibration isolators, seismic and wind restraints, and for designing vibration isolation bases.
    a) Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 15 Sections for equipment mounted outdoors.
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.
4) Seismic-Restraint Details:
    a) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
    b) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c) Coordinate seismic-restraint and vibration isolation details with wind restraint details required for equipment mounted outdoors. Comply with requirements in other Division 15 Sections for equipment mounted outdoors.
    d) Preapproval and Evaluation Documentation: By OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

e. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.
f. Welding certificates.
g. Qualification Data: For professional engineer and testing agency.
h. Field quality-control test reports.

7. Miscellaneous: Prior to installation, submit to Construction Supervisor on the job site, two copies of the following:
a. Shop Drawings of equipment layouts
b. Installation instructions for each piece of mechanical equipment furnished.
c. Dimension drawings for mechanical equipment pads and curbs including bolt sizes and locations.

8. Submittals required by these specifications, include drawings, calculations, brochures, samples, etc. shall be submitted as one package. Partial submittals will be returned unprocessed.

D. Record Drawings and Operating and Maintenance Books

1. Record Drawings (Refer to Division 1): On completion of work, furnish the Owner through the Architect, with a complete set electronic record drawings and shop drawings which properly reflect the locations of all equipment, fixtures, piping, ductwork, diffusers, mixing boxes, controls, etc., as actually installed. Where necessary to locate concealed equipment, dimensions, shall be included on these drawings. Maintain a separate set of drawing prints at the job site for such marking of "As-Built" locations. This set shall be updated as the installation work progresses and shall be available to the Architect at job visits. The Contractor shall indicate on the "As-Built" Drawings all deletions in green. Additions, relocations, rerouting and modifications shall be indicated in red.
2. The format shall be AutoCad 2015 or later. A CD with the electronic model will be supplied to the successful bidder for this purpose. Monthly changes shall be made to the drawings on a layer named "record" and the color shall be green. A copy of the model on CD with any "as-built" changes shall be submitted to the Architect along with all payment applications.
3. At the end of the project, the Contractor shall take "as-built" drawings modifying the electronic drawing files to show all changes, modification or additions made during construction. These drawings will become "Record Drawings" to be delivered to the Architect.
4. Final Record Drawings shall include legends, schedules, plans, sections and details.
5. Record Drawings shall be marked on the lower right corner with the following:
   a. Name of Contractor
   b. Record Drawings
   c. Date
   d. Building Permit Number
   e. Letter shall be bold and print 1/4 inches high minimum.
6. Contractor shall submit to the Architect, Record Drawings as follows:
   a. Four CDs (AutoCad 2015 or later)
   b. One reproducible set of drawings
   c. Four sets of drawings
7. The Architect will distribute the final Record Drawings as follows:

	OWNER	ARCHITECT	ENGINEER
CDs	1	1	1
Reproducible drawing set	1	0	0
Drawing Sets	1	1	1

8. Delivery of complete set of Record Drawings is one condition for the release of Contractor's final payment under the Contract.

E. Operating and Maintenance Books

1. Operating and Maintenance Books (Refer to Division 1): Provide the Owner through the Architect, operating instructions and maintenance data books for all equipment and materials furnished under this Division.
2. Submit five copies of operating and maintenance data books to the Architect for review two weeks before final inspection of the project. Assemble data in a single complete indexed volume and identify the size, model and features indicated for each item, as follows:

a. Identification readable from the outside of the cover, stating “Heating, Ventilating and Air Conditioning and/or Plumbing and/or Fire Protection Installation. Owner, by (name of company).”
b. Neatly typewritten index near the front of the manual, furnishing immediate information as to location in the manual of emergency data regarding the installation.
c. Complete instructions regarding the operation and maintenance of all equipment involved.
d. Complete nomenclature of replaceable parts, their part numbers, current cost and name and address of the nearest vendor of replacement parts.
e. Valve identification table keyed to valve I.D. number (e.g. V-1) on brass tag attached to each valve. Table shall indicate type of valve, product or service (e.g. domestic cold water), and function (e.g. shut-off, balancing, etc.).
f. Copy of guarantees and warranties issued on the installation showing dates of expiration.
g. Copy of the Air and Water Balancing Reports.

1.10 EXPLANATION AND PRECEDENCE OF DRAWINGS

A. For purpose of clearness and legibility, the drawings are essentially diagrammatic although size and location of equipment is drawn to scale wherever possible. The Contractor shall make use of data in contract documents and shall verify this information at building site.

B. Attention is called to the inclusion of flow diagrams, riser diagrams and details. Diagrams are not for the purpose of giving physical dimensions or locations, but rather to clarify sizes and the interconnections of the piping and of the various units of the process.

C. Other drawings of the contract set are hereby made a part of these specifications and shall be consulted by the Contractor and his work adjusted to meet the installation conditions.

D. Drawings indicate required size and termination of pipes and ducts and suggest proper routes of piping and duct to conform to the structure, to avoid obstructions and to preserve clearance. However, it is not the intention to indicate necessary offsets and it shall be the responsibility of the Contractor, under this section, to install ductwork and piping in such a manner as to conform to structure, avoid obstructions, preserve headroom, keeping openings and passageways clear, and make equipment requiring inspection, maintenance and repair accessible without further instructions or extra cost to the Owner.

E. Changes in location on piping, apparatus and equipment as indicated on the drawings shall be made to meet the architectural and structural conditions as required and acceptable to the Architect. Changes in work which has not been installed shall be made by Contractor without additional compensation, except changes which are caused by architectural and structural changes which increase the lengths of pipe or duct runs.

F. Contractor shall coordinate with other trades so that no interferences shall occur, as no extras will be allowed for changes made necessary by interferences with the work between trades.

G. CAD files plots and reproductions for this project are the property and instruments of service of dHA+CALPEC. dHA+CALPEC reserves and retains copyright authority, privileges and rights.
1. Upon request and subject to some limitations dHA with their client’s approval, may allow contractors and/or vendors to acquire and use copies of the electronic media file data for preparation of:
a. Fabrication of shop drawings for this project.
b. Submittals pertaining to this project.
c. Record documents.

2. Applicable limitations include:
    a. The Contractor or vendor acquiring these files agrees to hold harmless dHA the Architect and Owner from liability and/or damages resulting from their use.
    b. The Contractor or vendor acquiring these data files assumes full responsibility for their use and for the correctness of any information or features contained therein.
    c. dHA does not warranty, (explicit or implied) the accuracy of the building backgrounds, or dimensions or features contained therein.
    d. Usage is limited to this specific project and the specific acquirer.
    e. The files are released solely for the convenience of the contractor or vendor acquiring same and CAD files may not be transferred to third parties without written prior approval.
    f. dHA shall remove seals, proprietary identification, etc.

1.11 COMPLETE PERFORMANCE OF WORK

A. Practices of the Trades: Work shall be executed in strict accordance with the best practice of the trades by competent workmen.

B. Complete Functioning of Work: Labor, materials, apparatus, and appliances essential to the complete functioning of the systems described and/or indicated, or which may be reasonably implied as essential, whether mentioned in these contract documents or not, shall be furnished and installed by the Contractor. In cases of doubt as to the work intended, or in the event of need for explanation thereof, the Contractor shall call upon the Architect for supplemental instructions.

C. Work not shown in complete details shall be installed in conformance with accepted standard practice.

1.12 CONTROL AND OBSERVATION

A. The Architect and Owner shall have the right to reject materials or workmanship, which in their opinion are not in accordance with this contract, to interpret contract provisions and the meaning of the drawings and specifications. The above named parties shall be allowed access to the work for observation at all times.

B. Defective work or work contrary to the contract documents may be rejected without regard to state of completion, even though said work has been accepted as a result of a previous observation.

1.13 APROVALS

A. Electrical equipment shall meet the listing requirements and bear a minimum of one of the following agency labels:
    1. Underwriter's Laboratories (UL)
    2. Electrical Testing Laboratories (ETL)

B. No equipment will be accepted on the jobsite without prior written approval.

1.14 GUARANTEES

A. In addition to specific guarantees mentioned in these specifications, the Contractor shall leave the entire installation in complete working order and fee from defects in materials, workmanship or finish. Contractor shall repair or replace at his own expense work or parts of work that may develop defects due to faulty material or workmanship during the tests and

within a period of one year after the work is accepted by the Owner. Contractor shall guarantee also to repair or replace with like materials existing work of the building or equipment, which is damaged during the repairing of such defective apparatus, materials or workmanship. The signing of the contract for his work covered by these specifications and of which they shall become a part, shall become a written guarantee on the part of the Contract to carry out the provisions of this section of these specifications.

1.15 SEISMIC RESTRAINT QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the CBC unless requirements in this Section are more stringent.

C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer with at least five years of seismic design experience.

1.16 DAMAGE BY LEAKS

A. During the time period from the date of contract until termination date of this guarantee, the Contractor shall be responsible for damages to the ground, walls, roads, building, piping systems, electrical systems, heating, ventilating and air conditioning systems, building equipment, furniture and other building contents caused by leaks in the piping systems or equipment being installed or having been installed by him. Repair work shall be done as directed by, in a manner satisfactory to the Owner at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 GENERAL

A. Standard of Quality: Materials and equipment shall be new and in good condition. The commercially standard items of equipment and the specific names mentioned in sections of Division 22 & 23 are intended to establish the standards of quality and performance necessary for the proper functioning of the mechanical work.

B. Variations: Since manufacturing methods vary, reasonable minor equipment variations are expected; however, performance and material requirements are minimum. The Architect retains the right to judge equality of equipment that deviates from the specifications.

C. Symbols are for identification. Symbols, capacities, sizes, and electrical characteristics are indicated on the drawings. Contractor shall make necessary provisions for installation of his equipment and for attaching or connecting his work to other trades.

2.2 FLASHINGS

A. Make pipes and vents passing through roof or outside wall waterproof with flashings and storm collars or counter flashings.

B. Except as otherwise noted or required, extend vent pipes passing through roof at least 12 inches above finished roofline.

C. Furnish and install on each pipe passing through the roof a galvanized sheet metal flashing assembly with eight-inch skirt.

D. Ductwork penetrating roof or exterior walls shall be flashed and counter flashed with galvanized sheet metal.

E. Furnish and install on each pipe passing through the roof a six-pound seamless lead flashing assembly with eight-inch skirt. Flashing shall have steel reinforced conical boot and be complete with open top cast iron counter flashing and permaseal waterproofing compound. For sanitary vent, provide a hood with a minimum 2 to 1 free area to vent pipe size.

F. Ductwork-penetrating roof or exterior walls shall be flashed and counter flashed with galvanized sheet metal.

2.3 PIPE SLEEVES

A. Provide pipe sleeves for mechanical piping.

B. Size pipe sleeves to permit placing pipe and specified isolation material for pipes passing through concrete or masonry walls or concrete slabs.

C. Sleeve for pipes through floor slabs standard weight black steel pipe with top of sleeve projecting 3” above finished floor. For waterproof sleeves, use J.R. Smith Fig. 172 or equivalent by Zurn or Josam.

D. Sleeves for pipes through walls shall standard weight black steel Schedule 40 pipe with ends flush with wall surfaces.

E. Seal pipes passing through fire rated walls or roofs. Use Dow Corning 3-6548 Silicone RTV Foam in the annular space between pipes and sleeves. Sealant through fire rated walls or roofs shall be rated with the same fire rating as the wall or roof.

F. Insulated pipe shall be insulated in sleeves, caulked and sealed as above. Use type CS-CW inserts as manufactured by Pipe Shields, Inc.

G. Pipes passing through exterior walls and concrete walls shall be sealed watertight with “Linkseal” as manufactured by Thunderline Corp. Method of installation as recommended by the manufacturer.

2.4 PIPE ISOLATORS AND COVERING PROTECTION

A. Pipe isolators: Provide each hanger or clamp for un-insulated piping with an isolation material, having metal backing, to isolate sound vibration and electrolysis. Provide Elcen “Isolator or appeared equal.” Isolator not required for fire protection automatic sprinkler piping, waste, vent and natural gas piping.

2.5 ELECTRIC MOTORS

A. Horizontal mounted fan and pump motors (close coupled excepted) shall be of the “Premium” efficiency type. Provide General Electric “Energy Saver,” Westinghouse” Tee 11”, U.S. Motors,”XB”, Baldor “Super E”, “Lincoln” “Ultimate El” motors or approved equal unless otherwise specified. Guaranteed minimum full load efficiencies shall be certified in accordance with Institute of Electrical and Electronic Engineers (IEEE) Standard 112 Test Method B, National Electric Manufacturers’ Association (NEMA) MG-1-12.53a, and shall meet or exceed the following minimum criteria:

GUARANTEED MINIMUM FULL-LOAD NOMINAL EFFICIENCY						
MOTOR HORSEPOWER	OPEN MOTORS			ENCLOSED MOTORS		
	1,200 rpm	1,800 rpm	3,600 rpm	1,200 rpm	1,800 rpm	3,600 rpm
1	80.0	82.5	--	80.0	82.5	75.5
1.5	84.0	84.0	82.5	85.5	84.0	82.5
2	85.5	84.0	84.0	86.5	84.0	84.0
3	86.5	86.5	84.0	87.5	87.5	85.5
5	87.5	87.5	87.5	87.5	87.5	87.5
7.5	88.5	88.5	87.5	89.5	89.5	88.5
10	90.2	89.5	88.5	89.5	89.5	89.5
15	90.2	91.0	89.5	90.2	91.0	90.2
20	91.0	91.0	90.2	90.2	91.0	90.2
25	91.7	91.7	91.0	91.7	92.4	91.0

1. 1/2-Hp and Larger: 460-Volt, 3-phase, 60-Hertz.
2. Smaller than 1/2-Hp: 115-Volt, 1-phase, 60-Hertz.

B. General:

1. Motors shall be started across the line unless otherwise specified. Motors shall be selected with low starting current and shall be designed for continuous duty to provide the running torque and pull-in-torque required to suit the load. Unless otherwise specified, all motors shall be single speed –1750 rpm.
2. Motors shall have standard drip-proof enclosure unless otherwise specified.
3. Motors exposed to weather shall be of the totally enclosed fan-cooled type.
4. Motors shall have a minimum service factor of 1.15. Motors shall be selected to operate at design conditions without exceeding nameplate ratings without operating using the service factor.
5. Motors shall be sealed or field-lubricated in which case the latter shall be provided with grease fittings.
6. Pump motors shall be selected to drive the pump through its characteristic curve, from 0 to 25% above the design flow, without exceeding rated full load nameplate horsepower. Pump motor nameplate rating shall not be exceeded in pump operation anywhere in the pump curve.

C. Three-Phase: Three-phase motors 10-Hp and smaller shall have cast iron or steel housings and shall be of the squirrel cage induction type. Three-phase motors 15-Hp and larger shall have cast iron housings and shall be of the squirrel cage induction type.

D. Single Phase: Single phase motors shall be capacitor-start type having internal thermal overload protection and with starting, pull-in and running characteristics to suit the load.

E. Where motor is an integral part of equipment, motor manufacturer shall be as recommended by the equipment manufacturer. However, all other items shall comply with these specifications.

F. Nameplate: A motor nameplate shall be securely affixed to each motor and shall clearly indicate the class of insulation and the service factor in addition to the usual electrical data.

G. Special Requirements: Refer to various sections of this Division for special requirement for specific items of equipment requiring motors.

H. Submittals: Manufacturer's data for equipment requiring motors shall be submitted for review. Indicate the motor manufacturer, motor horsepower, voltage, speed, efficiency, special torque requirements, enclosure and other special requirements.

2.6 MOTOR CONTROLLERS

A. Where required: In general, motor controllers for motors shall be furnished and installed under Division 16 unless indicated or specified otherwise. A motor controller that is not an integral part of a piece of equipment shall be furnished under this Division and shall be installed in accordance with the following specifications.

B. General: The motor controller shall be steel mounted. Controllers shall be front wired and terminals shall be accessible for wiring directly from the front. No slate or ebony asbestos shall be permitted on any size controller from size 00 through size 8. Contacts shall be solid silver cadmium oxide alloy. Bare copper or silver flashed contacts shall not be permitted. Operating coils shall be pressure molded and so designed that if accidentally connected to excessive voltage, they will not expand, bubble or melt. When a coil fails under over-voltage condition, the motor controller shall definitely drop and not freeze the contacts in the "on" position.

C. Overload Relays: Overload relays shall be furnished for all three phases and shall be of the hand-reset variety so that blocking the reset mechanism in the reset position will not prevent the starter from dropping out if the motor is overloaded. This specifically excludes those overload relays which change to automatic reset from hand-reset when the reset mechanism is blocked unless the automatic reset feature can be removed or voided. Accidental depressing of the reset button or mechanism shall not shut off the motor. Overload relays shall not be field convertible from hand to automatic reset type.

D. Interlocks: Provide space to field-add one or more extra N.O. or N.C. interlocks to all (except size 00) motor controllers without removing existing wiring or removing the controller from its enclosure.

E. Bulletin Numbers: A full voltage magnetic motor controller to be furnished under this Division shall be similar and approved equal to Allen-Bradley (AB) Bulletin Numbers as follows:
   1. Individual three phase motor controller – AB Bul. 709.
   2. Individual single phase motor controller – AB Bul. 709SP.
   3. Combination three phase motor controller with fusible or nonfusible disconnect switch – AB Bul. 712.
   4. Combination three motor controller with circuit breaker –AB Bu. 713.
   5. Individual three multi-speed motor controller for two speed, single or two winding motors –AB Bul. 716.
   6. Combination three phase multi-speed controller with circuit breakers for two speed, single or two winding motors –AB Bul. 717.

F. NEMA Type: In general, motor controller enclosures shall be NEMA Type 1 general purpose unless exposed to the weather or otherwise indicated on the drawings. A motor controller including variable frequency drives exposed to the weather shall have NEMA Type 3R watertight enclosure.

G. Holding Coils: General holding coils in full voltage magnetic motor controllers shall be suitable for use on 120-VAC control voltage.

H. Overload Protection: Three phase full voltage magnetic motor controller shall be suitable for us on 120-VAC control voltage.

I. Manual Controllers: Manual motor controllers where indicated on the drawings, required and/or specified shall be similar and equal to Allen Bradley Bul. 600 in NEMA Type 1 enclosure or otherwise required for the location of the installation.

J. Accessories: Motor controllers shall be provided with accessories such as control power transformers, push buttons, selector switches, pilot lights, etc., as indicated on the drawings and as specified herein. In general, most motor controllers shall include a maintain-contract start-stop button or run switch.

K. Manufacturer: Allen-Bradley or approved equal.

2.7 BELT DRIVES AND GUARDS

A. Belt Driven Equipment: Provide with V-belt type, adjustable-pitch driving sheaves for up through 25-Hp motors. Motors 30-Hp and above shall have fixed pitch. Provide additional drive changes for motors when necessary to meet specified CFM for final air balance (one change minimum) at no additional cost to owner.

B. Drives: Minimum horsepower rating of 1.5 times motor nameplate horsepower.

C. Sheaves: Cast iron machined and balanced and keyed to shaft and locked with Allen type set screws.

D. Pitch Diameters: Minimum 3-inch for A section belts, minimum 5-inch for B section belts.

E. Guards: Provide belt drives with guards per OSHA requirements, metal construction, with angle iron framework with 1/2-inch expanded metal front panels and removable section held in place with studs and wing nuts for easy replacement of belts. Provide openings at shaft ends for tachometer readings.

2.8 ESCUTCHEONS

A. Provide heavy chrome-plated or nickel plated plates or approved pattern on pipe passing through floors, walls and ceilings in finished areas. Escutcheons shall be chrome-plated steel plates with concealed hinges and setscrew. Pattern shall be approved by the Architect.

2.9 ACCESS COVERS AND ACCESS DOORS

A. Access covers and doors locations shall coordinate with Architect.

B. Provide access door over concealed mechanical valves, controls, duct coils, dampers, fire dampers, pipe chases, concealed mechanical equipment through fire rated walls and ceilings.

C. Provide access doors for access to mechanical equipment valves.

D. Provide rated access covers or doors when required by the ceiling and wall fire rating.

E. Access Doors – Walls and ceilings:
   1. Type: Flush or recessed panel.
   2. Size: Minimum 12 x 12-inch nominal door for hand access, minimum 16 x 20-inch nominal door for personal access.

3. Location and style:

Masonry/concrete walls	Milcor “M” Standard
Gypsum wallboard walls and ceilings	Milcor “M” Standard
Plastered surfaces (except toilet walls)	Milcor “K” Standard
Tile/terrazzo/toilet room walls (with casing bead stainless)	Milcor “M” Standard
Acoustical tile (check type of ceiling system)	Milcor “A”
General areas	Milcor “M” Standard
Fire rated shafts, rated walls and ceilings	Milcor “B” Standard

4. Material:
   a. Stainless Steel, No. 302 with No. 4 finish.
   b. Standard manufacturer’s standard construction and finish for type specified.
5. Locking:
   a. Screwdriver: Flush screwdriver operated with case hardened cam.
6. Acceptable Manufacturers Milcor, Zurn, Miami, Carey, Potter-Roemer.

2.10 SEISMIC-RESTRAINT DEVICES

A. Basis-of-Design Product and Systems: Subject to compliance with requirements, provide Mason Industries or a comparable product by one of the following:
   1. International Seismic Application Technology
   2. Kinetics Noise Control
   3. Loos & Co.; Cableware Division
   4. Mason Industries
   5. TOLCO Incorporated; a brand of NIBCO INC.

B. Provide seismic restraints and seismic bracing equipment and systems as described in Part 3 and the Mason Industries Seismic Restraint Guidelines for acceptable restraint methods and OSHPD approved details.

C. Seismic Restraint Types
   1. Type II: Resilient Seismic Snubber. Mason Z-1011. Each corner or side of equipment base shall incorporate a seismic restraint having a minimum of 5/8-inch thick, all directional resilient pad limit stop. Restraints shall be fabricated of plate, structural members or square metal tubing. Angle bumpers are not acceptable.
   2. Type III: Cable or Brace Restraint. Mason SCB and SSB. Multiple metal cable or steel strut type with approved fastening devices to equipment and structure. System to be field bolted to deck or overhead structural members using two sided beam clamps or appropriately designed inserts for concrete.
   3. Type IV: Spring Neoprene Hanger. Mason 30N. Double deflection neoprene isolator min. 0.15-inch encased in ductile iron or steel casing.
   4. Type V: Non-isolated equipment shall be field bolted or welded (powder shots not acceptable) to the structures as required to meet seismic forces. Bolt diameter, imbedment data, and/or weld length must be shown in certified calculations as noted above.

D. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by OSHPD or 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 four times the maximum seismic forces to which they will be subjected.

E. 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 air gap, and minimum 1/4-inch thick resilient cushion.

F. Channel Support System: 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.

G. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

H. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.

I. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

J. 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.

K. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water resistant neoprene, with a flat washer face.

L. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

M. 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 E 488.

N. Factory Finishes
   1. Finish: Manufacturer's standard prime-coat finish ready for field painting.
   2. Finish: Manufacturer's standard paint applied to factory-assembled and - tested equipment before shipping.
      a. Powder coating on springs and housings.
      b. Hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
      c. Baked enamel or powder coat for metal components on isolators for interior use.
      d. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 SUPERVISION

A. The Contractor shall furnish the services of a Superintendent experienced in the work of each section who shall be constantly in charge of the progress of the work, together with all the necessary journeymen, helpers and laborers required to properly unload, erect, connect, adjust, start, operate and test the work involved.

3.2 PROTECTION, CARE AND CLEANING

A. The premises shall be maintained as required by Division 1.

B. Materials and Equipment:
   1. Effectively protect materials and equipment to be installed on a project against moisture, dirt and damage during the construction period, to the entire satisfaction of the Owner. Special care shall be taken to provide protective and similar equipment that are particularly vulnerable to grit and dirt.
   2. Keep interior of ductwork free of dirt, grit, dust, installation and other foreign materials. Do not operate air distribution equipment until building is cleaned and air filters installed in order to prevent soiling of diffusers, ducts, air handling equipment, and buildings. Provide new set of filters after final acceptance of air distribution systems.
   3. Drain and flush piping to remove grease and foreign matter. Thoroughly clean out valves, traps, strainers, and demonstrate the cleanliness to the Owner.

3.3 DISPOSITION OF MATERIALS

A. Refer to Divisions 1 and 2.

3.4 CLEAN-UP

A. Debris and Rubbish: Remove and transport debris and rubbish in a manner that will prevent spillage on pavement, streets, or adjacent areas. Limits to 3/4-cubic yard capacity buggies or other conveyances used roofs and within the building to transport removed debris. Clean up spillage from pavement, streets and adjacent areas.

3.5 INSTALLATION

A. General: Inspect the architectural, structural, plumbing, fire protection, special systems and HVAC drawings and specifications to become familiar with the building construction and to coordinate with the work of others.

B. Piping: Install in strict accordance with manufacturer's written installation instructions and recommendations. Install in a manner that permits expansion and contraction caused by changes in temperature and pressure. Provide additional support as required. Run pipes straight and true, parallel to or at right angles to the building walls. Springing or forcing piping into place will not be permitted.

C. Fixtures and Equipment: Install in strict accordance with manufacturer's written installation instructions and recommendations. Fixtures (except for handicapped) shall be roughed in only from fixture manufacturer's certified "Rough-In Measurement Drawings" which shall be submitted to the Architect for approval. Handicapped fixtures shall be installed in accordance with 2007 California Building Code rough-in measurements adjusted from manufacturer's certified drawings.

3.6 STAGING AND HOISTING

A. Provide hoisting equipment, staging scaffold, ladders, barricades, shores or similar facilities required to properly carry out this work in accordance with all safety regulations.

3.7 ENCLOSURES AND BARRICADES

A. The Contractor shall provide, install and maintain for the duration of the work as required, lawful and necessary barricades and railings, lights, warning signs and signals and shall take other precautions as may be required to safeguard persons, the site and adjoining property, including improvements thereon, against injuries and damages of every nature whatsoever. This requirement applies continuously (24-hours, 7-days a week) for the duration of this contract and is not limited only to regular working hours.

3.8 CONTROL AND INSPECTION

A. The Architect or Owner shall have the right to reject materials and workmanship which in his opinion are not in accordance with this contract, to interpret contract provisions and the meaning of the drawings and specifications.

B. The above named parties shall be allowed access to the work for observations at all times.

C. Defective work contrary to the contract documents may be rejected without regard to state of completion, even though said work has not been rejected as a result of a previous observation.

3.9 SLEEVES, CUTTING AND PATCHING

A. The Contractor shall be responsible for the sizing and timely placing of sleeves of piping and insulation material passing through walls, partitions, beams, floors and roof while same are under construction. If a pipe is insulated, its pipe sleeve shall be larger than the outside diameter of the insulation around the pipe. Sleeves set in concrete floor construction shall be minimum 20-gage galvanized steel. If holes and/or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no expense to the Owner by parties approved by the Architect.

B. Openings into existing masonry shall be core drilled or saw cut. The Contractor shall undertake no cutting or patching without first securing the Architect's written approval. Where a pipe passes through a sleeve, provide 1/2-inch minimum clearance. No joint of the pipe (or its insulation) shall touch the sleeve. Caulk around such pipe with sufficient layers of 1/8-inch neoprene and seal off opening between pipe and sleeve with non-hardening mastic.

C. Caulking in fire walls or floors shall be made using a UL listed, fire-rated material. For pipe or conduit penetrations through fire rated floors, walls, partitions, ceilings, etc., provide firestop system complying with the UL "Fire Resistance Directory" for "Through Penetration Firestop Systems" (XHEZ).

3.10 ANCHOR BOLTS

A. Furnish and install anchor bolts for equipment placed on concrete equipment pads or on concrete slabs. Bolts shall be of the size and number recommended by the manufacturer of the equipment and shall be located by means of suitable templates. When equipment is placed on vibration isolators, the equipment shall be secured to the isolator and the isolator to the floor, pad, or support as recommended by the vibration isolation Manufacturer.

3.11 LUBRICATION

A. Where Necessary: Provide means for lubricating bearings and other machine parts. If a part requiring lubrication is concealed or inaccessible, extend a lubrication tube with suitable fitting to an accessible location and identify it.

B. After Installation: Properly lubricate parts requiring lubrication and keep them adequately lubricated until final acceptance by Owner.

3.12 INSTALLATION OF EQUIPMENT

A. Floor mounted equipment shall be set on housekeeping pads extending minimum 6-inch beyond sides of the equipment. Housekeeping pads shall be minimum 4-inch high unless otherwise shown on drawings.

B. Equipment shall be secured in place using fasteners as recommended by SMACNA's Guideline for Seismic Restraints of Mechanical Systems latest edition.

C. Vibration Isolation: Vibration of motors, fans and other moving machinery shall be effectively isolated to prevent vibration transmission to building. Isolation shall prevent noise transmission through structure and slabs. Equipment shall be set on or suspended from neoprene and steel spring vibration dampeners of proper rating as specified herein, as shown on drawings, or as otherwise required. Fans and motors shall be secured to a common base.

3.13 INSTALLATION OF VALVES

A. General:
   1. Valves shall be full line size unless otherwise noted. Automatic control valves are exempted.
   2. Valves shall have proper clearances for handle operation and shall close tight at the specified test pressure.
   3. Pump discharge check valves shall be of non-slam type.

B. Arrangement
   1. Valves shall be installed in the systems so located, arranged and operated as to give complete regulation of apparatus, equipment and fixtures.
   2. Valves shall be installed for accessibility and easy maintenance.
   3. Gate valves shall be installed with stems horizontal to vertically upright.
   4. Balance Valves: Install balance valves where shown.

C. Location:
   1. On both inlet and outlet of all apparatus and equipment.
   2. For shutoff of branch mains.
   3. Where shown on the drawings.
   4. Ahead of each automatic control or regulation valve in water lines.

3.14 PIPE SUPPORTS

A. Installation:
   1. Securely support piping from building construction with manufactured iron hangers, brackets, trapezes, guides, anchors and sway braces to maintain pipe alignment and prevent sagging, noise and excessive strain due to uncontrolled movement under

operating conditions. Auxiliary secondary beams shall be furnished and installed under this division of the specifications wherever necessary to meet the requirements above.

2. Piping supports for each system shall be engineered as a system and the proposed system submitted for review.
3. Relocate hangers as necessary to correct unsatisfactory conditions that may become evident when system is put into operation.
4. Support of piping by wire, rope, wood or other make shift devices will not be permitted.
5. Burning of holes in beam flanges or narrow members will not be permitted.
6. Where calculated maximum travel due to thermal expansion exceeds 1 inch, provide rollers at supports.
7. Piping shall not be supported from roof decking. Furnish and install auxiliary steel members to span steel purlins to distribute the load. Refer to roof shop drawings for location of beams and purlins.
8. Sheet lead, lead wool or wood plugs shall not be accepted as a substitute of cinch anchors as a means of attaching materials and equipment to concrete.
9. Support for insulated pipe shall be outside the insulation. Protect pipe insulation at every hanger, support or guide with inserts and shields. The galvanized sheet shield shall be applied between the hanger or support and the pipe insulation. Provide saddles at all rollers of insulated pipe not equipped with inserts and shields.

3.15 SEISMIC RESTRAINT

A. Examination
   1. 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.
   2. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
   3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Applications
   1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by OSHPD or an agency acceptable to authorities having jurisdiction.
   2. 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.
   3. 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.

C. Seismic Restraint Installation
   1. Install seismic restraint devices as necessary to meet AHJ requirements.
   2. Equipment Restraints:
      a. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
      b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125-inch.
      c. Install seismic-restraint devices using methods approved by OSHPD or an agency acceptable to authorities having jurisdiction providing required submittals for component.
   3. Piping Restraints:
      a. Comply with requirements in MSS SP-127.

b. Space lateral supports a maximum of 40-ft on center, and longitudinal supports a maximum of 80-ft on center.
c. Brace a change of direction longer than 12-ft.

4. Install cables so they do not bend across edges of adjacent equipment or building structure.
5. Install seismic-restraint devices using methods approved by OSHPD or an agency acceptable to authorities having jurisdiction providing required submittals for component.
6. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
7. 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.
8. 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.
9. Drilled-in Anchors:
   a. 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.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. 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.
   d. 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.
   e. Set anchors to manufacturer's recommended torque, using a torque wrench.
   f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
10. Seismic Restraint Application
    a. Floor mounted equipment whether isolated or not shall be snubbed, anchored, bolted or welded to structure to comply with the requirements of these specifications. Calculations that determine that isolated equipment movement may be less than the operating clearances of snubbers (restraints) do not preclude the need for snubbers. Equipment shall be positively attached to the structure.
    b. Suspended equipment and apparatus shall be two or four point independently braced with Type III restraints, installed taught for non-isolated equipment and slack with 1/2-inch cable deflection for isolated equipment. Suspending rods shall be braced as necessary to restrain against angular motion. VAV Boxes (without fans) attached directly to ductwork on the main supply side shall be considered as ductwork for seismic design purposes. Fan powered VAV boxes shall be considered as equipment.
    c. Suspended pipe, duct, cable trays, bus duct and conduit shall be restraint Type III or V.
    d. For trapeze supported piping and conduit, the individual pipes and conduits shall be transversely and vertically restrained to the trapeze support at each restraint location.
    e. For overhead supported components, overstress of the building structure must not occur. Bracing shall occur from:
       1) Flanges of structural beams
       2) Upper truss chords in bar joists.

3) Cast in place inserts or drilled and shielded inserts in concrete structures.

f. Pipe Risers

1) Where pipes pass through cored holes, core diameters shall be a maximum of 2-inch larger than pipe O.D. including insulation. Cored holes must be packed with resilient material or firestop as specified in other sections of this specification and/or state and local codes. No additional horizontal seismic bracing is required.

2) Non-isolated, constant temperature pipe risers through cored holes require a riser clamp at each floor level on top of slab attached in a seismically approved manner for vertical restraint.

3) Isolated and/or variable temperature risers through cored holes require Type K riser resilient Guides and Anchors installed to meet both thermal expansion and seismic acceleration criteria. Each floor level shall have either a riser clamp that does not interfere with the thermal expansion/contraction of the pipe or a riser clamp/cable assembly (also non-interfering) capable of supporting the weight of the pipe between floors in the event of pipe joint failure. Riser guides and anchors shall also be selected to serve as seismic restraints.

g. Non-isolated floor or wall mounted equipment and tanks shall use restraint Type III or V.

h. Where base anchoring of equipment is insufficient to resist seismic forces, restraint TYPE III shall be located above the component's center of gravity to suitably resist "G" forces specified. Vertically mounted tanks and upblast tubular centrifugal fans, tanks, or similar equipment, may require this additional restraint.

i. A rigid piping system shall not be braced to dissimilar parts of building on two dissimilar building systems that may respond in a different mode during an earthquake. Examples: Wall and roof; solid concrete wall and a metal deck with lightweight concrete fill, pipes, duct, conduit, etc., crossing a building expansion joint.

D. Exclusions From Seismic Restraint Requirements

1. With the exception of life safety components, certain components do not require seismic restraints.

2. The exclusions from seismic restraint requirements DO NOT apply for Life Safety Components as follows:

a. Piping: Fire protection, fuel oil, gasoline, natural gas, medical gas, compressed air, medical piping or piping that contains hazardous or corrosive materials that is 1-inch nominal diameter and larger.

b. Duct: Smoke evacuation duct or fresh air make-up connected to emergency system

3. With the exception of life safety components, the following items do not require seismic restraints:

a. Curb mounted mushroom, exhaust and vent fans with curb area less than nine square feet in cross sectional area.

b. Square or rectangular duct with less than 6-ft^2 cross sectional area.

c. Round air handling duct less than 28-inch in diameter.

d. Duct supported at locations by two rods less than 12-inch in length from the structural support to the structural connection at the ductwork with positive attachment to the structure.

e. Piping less than 2-1/2-inch diameter.

f. Clevis or trapeze supported piping suspended by hanger rods less than 12-inch in length (6-inch or less for fire sprinkler piping) with positive attachment to structure.

E. Accommodation Of Differential Seismic Motion

1. 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.

Comply with requirements in Division 15 Sections HVAC, Plumbing, and Medical Gas for piping flexible connections.

F. Field Quality Control
   1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
   2. Perform tests and inspections.
   3. Tests and Inspections:
      a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
      b. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
      c. Obtain Architect's approval before transmitting test loads to structure.
      d. Provide temporary load-spreading members.
      e. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
      f. Test to 90% of rated proof load of device.
      g. Measure isolator restraint clearance.
      h. Measure isolator deflection.
      i. Verify snubber minimum clearances.
      j. If a device fails test, modify installations of same type and retest until satisfactory results are achieved.
   4. Remove and replace malfunctioning units and retest as specified above.
   5. Prepare test and inspection reports.
      a. Upon completion of installation of seismic restraint devices, a certification report prepared by the manufacturer shall be submitted in writing to the contractor indicating that systems are installed properly and in compliance with the specifications. The report must identify those areas that require corrective measures or certify that none exists. Field coordination changes to the originally submitted seismic restraint designs must be clearly defined and detailed in this report.

G. Adjusting
   1. Adjust isolators after piping system is at operating weight.
   2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
   3. Adjust active height of spring isolators.
   4. Adjust restraints to permit free movement of equipment within normal mode of operation.

H. Demonstration
   1. 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."

3.16 IDENTIFICATION OF EQUIPMENT, DUCTWORK, PIPING AND VALVES

A. Equipment Labels: Equipment furnished and installed under this section shall be provided with manufacturers metal labels securely attached to each individual piece of equipment and showing complete and comprehensive performance characteristics, size, model, serial number etc.

B. Name Plate: Install engraved Bakelite nameplates with 1/4-inch high white letters for equipment, switches, controls, room stats, damper motors, indicating zones, etc.

C. Valves shall have tags attached with “S” mounting. Tags shall be at least 1-1/2-inch in diameter. Tags shall be stamped with valve I.D. number (e.g. V-1) and be keyed to valve identification table submitted as part of the Operating Instruction and Maintenance Manuals.

D. Dampers: Mark volume dampers above new or existing ceilings by attaching a bright yellow 12-inch length strip of cloth attached to damper rod. Groove ends of shafts to indicate open and closed position.

E. Piping exposed to view shall have color coded markers as to type of use, service, and direction of flow in accordance with the latest edition of ANSI A 13.1. Locate markers at each valve, at entries to walls, and on 20-ft centers on straight runs of pipe. Provide a flow arrow at each identification marker. Labels or markers shall be made of plastic sheet with pressure sensitive adhesive suitable for the intended application.
   1. Color Coding for Labels and Bands by Hazard Classification:
      a. Dangerous Materials – Yellow:
         1) Heating hot water – yellow with black letters

F. Nameplate designations shall correspond to the identifications on the “Record Drawings.”

G. Submit to the Architect for approval a list of items to be tagged within two weeks after award of the Contract.

3.17 CLEANING

A. Equipment, piping, ductwork, and related valves and appurtenances, etc. Clean so as to remove rust, scale, plaster or internal obstructions before covering is installed or piping or equipment is painted. No scarring or disfiguring of equipment, piping, etc. will be acceptable before covering or painting is applied.

B. Painted Work: Parts of the work, which are to be painted or which are exposed in the finished work shall be thoroughly cleaned and made ready to receive paint finish.

C. Exposed Equipment: The exposed parts of equipment shall be cleaned, oil and grease removed, and the bright parts left clean and polished.

D. Completion: Upon completion of the work, the Contractor shall remove rubbish, debris and surplus materials, resulting there, from the premises together with test instruments, and equipment and shall leave the site in a neat, clean and acceptable condition as approved by the Architect.

3.18 FLUSHING OF PIPE SYSTEMS

A. Entire pipe systems shall be flushed and cleaned of foreign matter before they are placed in service. The length and number of flushing cycles shall be governed by the complexity of the system, but in no case less than two cycles.

B. Flushing shall be performed using a similar media that is to be carried by the piping system. (Example: Cold water piping – water; etc.)

C. Where pipe strainers have been designed or installed into the piping network, said strainers shall be opened and strainer baskets removed and cleaned several times during the flushing of the system.

D. Chemical Cleaning: For chemical cleaning of closed circuit systems see Section 15500.

3.19 CORROSION PROTECTION

A. Protective coverings for underground steel piping shall be installed in strict accordance with manufacturer's written installation instructions.

B. Testing: Covered pipe shall be tested with high voltage holiday tester in the presence of Architect prior to backfilling all holidays shall be repaired and retested.

C. Plastic sleeves, rubber seals, or other dielectric material shall be used to isolate piping from the building structure where steel piping penetrates concrete floor slabs or walls.

3.20 PAINTING

A. Painting:
   1. Finish painting of mechanical equipment shall be as specified in Division 9, unless otherwise specified in Division 15.
   2. Equipment shall be provided with factory applied prime finish, unless otherwise specified.

B. Touch-Up: If the factory finish on any equipment furnished by the Contractor is damaged in shipment or during construction of the building, the equipment shall be refinished by the Contractor to the satisfaction of the Architect.

C. Concealed Materials: Uncoated cast iron or steel that will be concealed or will not be accessible when installations are completed shall be given one heavy coat of black asphalt before concealment.

3.21 ELECTRICAL WORK

A. Furnish electrical interlock wiring diagrams and complete sequences of operation for equipment specified in Division 16 that must interface with other electrical, mechanical, or control equipment. These diagrams shall be submitted to both the mechanical, and electrical engineers for review and coordination.

B. Furnish any additional line or low voltage, mechanical and control system wiring and conduit required over and above that specified in Division 16 as required for complete and functional systems is hereby specified in this Division in complete conformance with the requirements outlined in Division 16 at no additional cost to the Owner.

3.22 PENETRATIONS

A. Duct and pipe penetrations of ceilings shall be sealed air tight with silicone caulking prior to installation of escutcheon rings.

B. Duct and pipe walls or slab penetrations shall be sealed using a UL listed fire rated material.

3.23 PRELIMINARY OPERATIONS

A. Should the Owner require that any portion of the system or equipment be operated prior to the final completion and acceptance of the work, the Contractor shall furnish such operation. The expense thereof will be paid, by the Owner separate and distinct from any money paid on account of the contract.

B. For such preliminary operation, payment shall not be construed as final acceptance of the work of this contract.

3.24 OPERATING INSTRUCTIONS

A. The Contractor shall provide the services of a competent Operating Engineer to supervise the operation of equipment specified herein and to instruct the Owner's operators during a three day operating period. The operating instruction period shall be defined as straight time working hours and shall not include nights and weekends.

B. The Owner shall be notified in writing at least five days before each operating instruction period begins. The Owner must indicate acceptance of the instructional starting time in writing to the Contractor. Upon arrival, the various instructors shall report to the Owner.

3.25 TESTS

A. Tests must be performed and systems approved prior to painting, covering, insulating, furring or concealing piping.

B. Provide test equipment, instrumentations and labor in conjunction with tests.

C. Prior to test, protect or remove control devices, air vent and other items, which are not designed to stand pressure used in test.

D. Accomplish testing of piping in section so as not to leave a portion of pipe or joint untested.

E. Obtain prior approval for test procedure.

F. Responsibility for Damages: Contractor shall pay for costs for repair and restoration of work of other trades damaged by tests or cutting done in connection with tests.

3.26 REPAIRS AND RETEST

A. Refer to related sections.

B. Make other adjustments, repairs and alterations required to meet specified test results.

C. Correct defects disclosed by tests or inspection; replace defective parts.

D. Use only new materials in replacing defective parts; in case of pipe, replace with same length as defective piece.

E. Repeat tests after defects have been corrected and parts replaced, until pronounced satisfactory.

3.27 MECHANICAL SYSTEMS STARTING

A. Start-up all operating systems provided under Division 23.

B. Demonstration of all operating systems provided under Division 23, including, but not limited to:
   1. Heating Hot Water Boiler
   2. Domestic Hot Water Heat Exchanger Storage Tank
   3. Pumps
   4. Control System

C. Sequencing: Conduct demonstrations only after systems have been through start-up procedures, systems are complete and operating and operating maintenance data is complete.

D. Verification of Conditions:
   1. Existing conditions: Examine preceding work to ensure that systems are operational.
   2. Verify with Division 26 contractor:
      a. Temporary services are disconnected and permanent utility services are capable of full loan.
      b. Connections in main switchgear and subpanels are tight.
      c. Necessary tests and check meter readings have been made.
   3. Mechanical:
      a. Specified tests on piping systems have been made.
      b. Specified cleaning of piping systems has been completed.
      c. Piping: Conformance with drawings, specifications, and ANSI B31.1. Replace or correct work rejected because of defects or nonconformance with drawings, specifications and ANSI B31.1.
      d. Water treatment has been completed.
      e. Operational and performance tests have been made.
      f. Each piece of equipment comprising part of system has been checked for proper control sequence, and any other condition which may cause damage to equipment or endanger personnel.
      g. Verify strainers are clean. Operate system 24 hours and recheck.
      h. Verify chemical pot feeder has proper chemicals.
      i. Verify control valves fully open and close.
      j. Verify heating and/or cooling equipment cool and heat as controller requests.
      k. Verify integrity of wiring.
      l. Verify sensors are provided and in correct location.
      m. Verify range of each device and check software is compatible sensor calibration.
      n. Test voltage on each input and output.
      o. Test start/stop points to verify correct equipment operates.
      p. Verify sequence of operation.
      q. Check sensor calibration.

E. Submit testing plan for review prior to testing. Indicate order of procedure, list items will be tested and order of testing show where controllers and devices are located.

F. Provide report indicating equipment operated properly and as per sequence of operation.

3.28 START-UP TESTING

A. Notification: Notify owner at least two days in advance of start-up of mechanical systems.

B. Start-up and Testing: Conduct start-up and start-up testing in presence of owners. See applicable Division 15 Sections for specific requirements.

C. Lubrication: Field check and field lubricate equipment requiring lubrication prior to initial operation.

D. Code Authorities: Complete tests required by code authorities including smoke detection, fire protection and health codes.

E. Control Systems: Ensure control systems are fully operational in manual and automatic modes.

F. Test equipment before and after installation as applicable where necessary to determine compliance with specifications.

G. Start-up and Testing: Conduct start-up and start-up testing in presence of Owner. See applicable Division 15 Sections for specific requirements.
   1. Periodically clean various strainers during initial operation until no further accumulation of foreign materials occurs. Exercise care so minimum loss of water occurs when strainers are cleaned.
   2. Adjust safety and automatic control instruments as necessary to place them in proper operation and sequence.

H. Field Tests: Subject the work of Division 15 to necessary field tests after installation and before acceptance.
   1. Make proper corrections, repairs and replacements should tests reveal evidence of malfunction. Repeat tests until proper and successful operation is achieved.
   2. If final control settings and adjustments cannot be properly made to performance tests because of time of year, make field tests as first seasonal use of systems following completion of project.

I. Cleaning and Adjusting: After test runs have been completed and systems have been demonstrated to be satisfactory and ready for permanent operation. Clean permanent pipeline strainers properly adjust valve and pump packings, secure drive guards in place, check lubrication and replenish if required.

J. Protection: If systems are not to continue in sue following start-up procedures, take steps to ensure against accidental operation or operation by unauthorized personnel.

K. Instruct Owner's representatives once on proper operation and maintenance of mechanical systems. Include seasonal concerns and operations.

L. Systems: Mechanical systems provided under Division 23. See applicable Division 23 Sections for additional requirements.

M. Contractor's Representatives: Have thorough knowledge of particular installation and system.

N. Manufacturer's Representatives: Have thorough understanding of each particular equipment and system.

O. Scheduling: Arrange and schedule demonstration times with Owner.

P. Location: Conduct demonstrations at Project including tours of systems.

Q. Operating and Maintenance Date: Arrange for data to be at demonstrations. Include review of data at demonstrations.

R. Time Allotment: Provide demonstration periods of following minimum time periods:
   1. Water Systems: 8 hours (HVAC) for each system.

S. Control Systems: 8 hours for each system.

3.29 COMPLETION DATE AND TESTING OF MECHANICAL SYSTEMS:

A. Final Acceptance Tests shall be sufficiently in advance of the contract completion date to permit the execution before that expiration of the contract of any adjustments and/or

alterations, which the final acceptance tests indicate as necessary for the proper functioning of equipment.

1. Modifications shall be completed within the number of days allotted for completion of the contract. Retests shall not relieve the Contractor of completion date responsibility.

B. Starting and Operation: Before starting or operating equipment of systems, make through check to determine that the systems have been flushed and cleaned as required and equipment has been properly installed, lubricated and serviced. Notify owner at least three days in advance of starting these tests.

3.30 FINAL REVIEW

A. Date and Time: At a time designated by the Owner, the entire system shall be reviewed by the Architect. The Contractor shall be present at this review.

B. System Operation: The system shall be operating properly within water and air volumes balanced and all temperature controls adjusted. Labels shall be removed from the plumbing fixtures, and the fixtures shall be cleaned and in operating condition. Air and Water Balance Report shall be submitted to the Owner.

C. Documentation: Certificates and documents required herein shall be in order and presented to the Architect at least two weeks prior to the review.

D. Changes and Corrections: After the review, changes or corrections noted by the Architect as necessary for the work to comply with these specifications and the drawings shall be accomplished without delay in order to secure final acceptance to the work.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 23 specification sections, drawings, and general provisions of the contract apply to work of this section, as do other documents referred to in this section.

1.2 SCOPE OF WORK

A. The owner's representative will directly retain a qualified test and balance firm for the HVAC system. This independent test requirement shall not be procured at the subcontractor level.

B. The work included in this section consists of furnishing labor, instruments, and tools required in testing, adjusting and balancing the HVAC systems, as described in these specifications or shown on accompanying drawings. Services shall include checking equipment performance, taking the specified measurements, and recording and reporting the results.

C. The items requiring testing, adjusting and balancing include the following:
   1. Hydronic Systems
      a. System Mains and Branches
      b. Coils

1.3 DEFINITIONS, REFERENCES, STANDARDS

A. Work shall be in accordance with the latest edition of the AABC National Standards. If these contract documents set forth more stringent requirements than the AABC National Standards, these contract documents shall prevail.

B. AABC: The Associated Air Balance Council is a nonprofit association of independent, certified agency specializing in testing, adjusting, and balancing HVAC systems. The AABC National Standards (latest edition), provides standards and operational criteria for HVAC Systems

1.4 QUALIFICATIONS

A. Agency Qualifications: The TAB Agency shall be a current member of the Associated Air Balance Council (AABC).

1.5 SUBMITTALS

A. Qualifications: The TAB Agency shall submit a company resume listing personnel and project experience in air and hydronic system balancing and a copy of the agency Test and Balance Engineer (TBE) certificates.

B. Procedures and Agenda: The TAB Agency shall submit the TAB procedures and agenda proposed to be used.

C. Sample Forms: The TAB Agency shall submit sample forms, which shall include the minimum data required by the AABC National Standards.

1.6 TAB PREPARATION AND COORDINATION

A. Shop drawings, submittal data, up-to-date revisions, change orders, and other data required for planning, preparation, and execution of the TAB work shall be provided to the TAB Agency no later than 30 days prior to the start of TAB work.

B. System installation and equipment startups shall be complete prior to the TAB Agency being notified to begin.

C. The Building Control System shall be complete and operational. The Building Control System contractor shall install necessary computers and computer programs, and make these operational. Assistance shall be provided as required for reprogramming, coordination, and problem resolution.

D. Test points, balancing devices, identification tags, valves, and dampers shall be accessible and clear of insulation and other obstructions that would impede TAB procedures.

E. Qualified installation or startup personnel shall be readily available for the operation and adjustment of the systems. Assistance shall be provided as required for coordination and problem resolution.

1.7 REPORTS

A. TAB Report – The TAB Agency shall submit the final TAB report for review by the engineer for each phase. Outlets, devices, and equipment shall be identified, along with a numbering system corresponding to report unit identification. The TAB Agency shall submit an AABC “National Project Performance Guaranty” assuring that the project systems were tested, adjusted and balanced in accordance with the project specifications and AABC National Standards.

B. Submit five copies of each TAB Report.

C. Contractor shall coordinate Test and Balance Activities so that sufficient time is available to review each TAB Report. Test and Balance Report shall have 10-days for review after being received by Mechanical Engineer. 10-day review period is applicable to all Test and Balance Reports, including retests. The Contractor shall be responsible for any delays in achieving occupancy due to not having completed and approved TAB report prior to OSHPD sign-off.

1. Request for expedited review less than the 10-day period shall be an additional service for the Mechanical Engineer.

1.8 DEFICIENCIES

A. Any deficiencies in the installation or performance of a system or component observed by the TAB Agency shall be brought to the attention of the appropriate responsible person.

B. The work necessary to correct items on the deficiency listing shall be performed and verified by the affected contractor before the TAB Agency returns to retest. Unresolved deficiencies shall be noted in the final report.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION

A. Instruments used for measurements shall be accurate and calibrated. Calibration and maintenance of instruments shall be in accordance with the requirements of AABC National Standards.

PART 3 - EXECUTION

3.1 GENERAL

A. The specified systems shall be reviewed and inspected for conformance to design documents. Testing, adjusting and balancing on each identified system shall be performed. The accuracy of measurements shall be in accordance with AABC National Standards. Adjustment tolerances shall be + or – 10% unless otherwise stated.

B. Equipment settings including manual damper quadrant positions, manual valve indicators, fan speed control levers, and similar controls and devices shall be marked to show final settings.

C. Information necessary to complete a proper TAB project and report shall be per AABC standards unless otherwise noted. The descriptions for work required, as listed in this section, are a guide to the minimum information needed.

3.2 HYDRONIC SYSTEMS

A. The TAB Agency shall, as applicable, confirm that hydronic equipment, piping, and coils have been filled and purged; that strainers have been cleaned; and that balancing valves (except bypass valves) are set full open. The TAB Agency shall perform the following testing and balancing functions in accordance with the AABC National Standards.

B. For System Mains and Branches:
   1. Adjust water flow in pipes to achieve maximum or design GPM.

C. For Pumps, Heat Exchangers:
   1. Tolerances – Test, adjust and balance and heating hot water flows within 10% of design requirements.
   2. Verification – Verify the type, location, final pressure drop and GPM of each coil. This information shall be recorded on coil data sheets.

3.3 ADDITIONAL TAB SERVICES

A. Preconstruction Plan Check and Review: The TAB Agency shall review the project documents and contractor submittals for their effect on the TAB process and overall performance of the HVAC System. It shall submit recommendations for enhancements or changes to the system within 30-days of document review.

B. Job Site Inspections: During construction, the TAB Agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the HVAC systems. Inspections shall be conducted at a minimum of twice. (Typically, these are performed when 60% of the total system is installed and again when 90% of the total system is installed, prior to insulation and again when 90% of the total system is installed, prior to insulation of the duct and piping). The TAB Agency shall submit a written report of each inspection.

C. Duct Leakage Testing: The installing contractor shall isolate and seal sections of ductwork for testing. The test pressures required and the amount of the duct to be tested shall be described by the engineer in the appropriate duct classification section. Testing shall be based on one test per section only unless otherwise noted.

D. Verification of HVAC Controls: The TAB Agency shall be assisted by the Building Control Systems Contractor in verifying the operation and calibration of HVAC and temperature control systems. The following tests shall be conducted:

1. Verify that control components are installed in accordance with project requirements and are functional, including electrical interlocks, damper sequences, air and water resets, fire and freeze stats, and other safety devices.
2. Verify that controlling instruments are calibrated and set for design operating conditions.
3. Temperature Testing: To verify system control and operation, a series of three temperature tests shall be taken at approximately two hour intervals in each separately controlled zone. The resulting temperatures shall not vary more than 2°F from the thermostat or control-set point during the tests. Outside temperature and humidity shall also be recorded during the testing periods.

E. TAB report verification: At the time of final inspection, the TAB Agency may be required to recheck, in the presence of the owner's representative, specific or random selections of data recorded in the certified report. Points and areas for rechecks shall be selected by the Owner's representative. Measurements and test procedures shall be the same as approved for the initial work for the certified report. Selections for rechecks, specific plus random, will not exceed 10% of the total number tabulated in the report.

END OF SECTION

SECTION 23 09 00

BUILDING CONTROL SYSTEM

PART 1 – GENERAL

1.1 Work Included:

A. GENERAL - Building Management System (BMS) Contractor shall provide and install:

1. A fully integrated Building Automation System (BAS), incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified.

2. Complete temperature control system to be DDC with electric actuation as specified herein.

3. All wiring, conduit, panels, and accessories for a complete operational system.

4. BMS Contractor shall be responsible for all electrical work associated with the BMS. Power to control panels is by Div 26 contractor.

   a. Perform all wiring in accordance with all local and national codes.
   b. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the division 26 specifications, NEC and local building code.
   c. Surge transient protection shall be incorporated in design of system to protect electrical components in all DDC Controllers and operator's workstations.
   d. All low voltage electrical control wiring throughout the building when exposed or in an un-accessible location shall be run in conduit in accordance with the division 16 specifications, local building code and the NEC. Low voltage wiring throughout the building, when in concealed accessible locations, can be run using plenum rated wire and supported from duct work or ceiling supports.

5. All wells for water monitoring devices, flow switches and alarms, as required.

6. Provide open communications system. The system shall be an open architecture with the capabilities to support a multi-vendor environment. To accomplish this effectively, system shall be capable of utilizing standard protocols as follows as well as be able to integrate third-party systems via existing vendor protocols.

   a. System shall be capable of high speed Ethernet communication using TCP/IP protocol.
   b. System shall be capable of BACnet communication according to ANSI/ASHRAE 135-2004.
   c. System shall be capable of OPC server communications according to OPC Data Access 2.0 and Alarms and Events 1.0.
   d. The system shall be capable of supporting both standard and vendor specific protocols to integrate a wide variety of third-party devices and legacy systems.
   e. The system shall be capable of supporting wireless field level networks and sensor communications using a mesh topology and IEEE 802.15.4 network.
   f. The intent is to either use the Operator Workstation provided under this contract to communicate with control systems provided by other vendors or to allow information about the system provided in this contract to be

sent to another workstation. This allows the user to have a single seat from which to perform daily operation.

7. Provide system graphics for each controlled device and/or integrated systems as required by the owner. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

8. Total of 1 (1) Personal computer operator workstations, associated peripherals and equipment required to set up dynamic color graphic PC console at the Maintenance and Operations Systems Room.

9. Stand-alone Application Specific Controllers (ASCs) for terminal equipment (CAV, FP VAV, and VAV units, and fan coil units).

B. GENERAL PRODUCT DESCRIPTION

1. The installation of the control system shall be performed under the direct supervision of the controls manufacturer with the shop drawings, flow diagrams, bill of materials, component designation, or identification number and sequence of operation all bearing the name of the manufacturer. The installing manufacturer shall certify in writing, that the shop drawings have been prepared by the equipment manufacturer and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that the shop drawings were prepared by their company and that all temperature control equipment was installed under their direct supervision.

2. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project.

3. The system shall be scalable in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O, and data collection. The failure of any single component or network connection shall not interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.

5. DDC Controllers shall be able to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall also be able to send alarm to multiple operator workstations without dependence upon a central or intermediate processing device.

6. DDC Controllers shall be able to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust or control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priority levels for every point shall be fully programmable and adjustable.

1.2 Products Furnished and Installed Under This Section

A. Hydronic Piping:
1. Control Valves
2. Temperature Sensor Wells and Sockets
3. Flow Switches
4. Flow Meters

1.3 Related Sections

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:

1. Section 23 05 00-Common Work Results for Mechanical
2.

1.4 Approved Control System Contractors and Managers

A. The following are the approved Control System Contractors and Manufacturers:
1. Climatic Building Technologies Group – Product Line: Alterton System.
2. System must match existing using campus standards as dictated by this specification. Gateway, integrator, or “blackbox” communications interfaces are not acceptable. All functionality of the System 600 Apogee shall be provided at new and existing workstations including but not limited to: trending, archiving, custom reporting, system profiler, programming scheduling etc.

1.5 Quality Assurance

A. The BAS system shall be designed and installed, commissioned and serviced by factory trained personnel. BMS contractor shall have an in-place support facility within 60 miles of the site with technical staff, spare parts inventory and necessary test and diagnostic equipment. The B.M.S. contractor shall provide full time, experienced project manager for this work, responsible for direct supervision of the design, installation, start up and commissioning of the B.M.S. The PM should be available by cell phone during normal working hours and on-site when directed for related meetings and coordination. The bidder shall be regularly engaged in the installation and maintenance of BMS systems and shall have a minimum of twenty (20) years of demonstrated technical expertise and experience in the installation and maintenance of B.M.S. systems similar in size and complexity to this project in the greater Los Angeles/Southern California area.

B. The BMS contractor shall maintain an established service organization consisting of factory trained service personnel and provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

C. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

D. All BAS peer-to-peer network controllers, central system controllers, and local user displays shall be UL Listed under Standard UL 916, category PAZX; Standard ULC C100, category UUKL7; and under Standard UL 864, categories UUKL, UDTZ, and QVAX and be so listed at the time of bid. All floor level controllers shall comply, at a minimum, with UL Standard UL 91 6category PAZX; Standard UL 864, categories UDTZ, and QVAX and be so listed at the time of Bid.

E. The BAS peer-to-peer network controllers and local user display shall also comply with the European Electromagnetic Compatibility (EMC) Framework, and bear the C-Tic Mark to show compliance. The purpose of the regulation is to minimize electromagnetic interference between electronic products, which may diminish the performance of electrical products or disrupt essential communications.

F. DDC peer-to-peer controllers shall be compliant with the European EMC Directive, Standards EN 50081-2 and EN 50082-2, at the Industrial Levels. Additionally the equipment shall be compliant with the European LVD Directive and bear the CE mark in order to show compliance to both directives.

G. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

H. All wireless devices, if used, shall conform to:

1. The requirements of Title 47 of the Code of Federal Regulations, FCC Part 15, governing radio frequency intentional radiating devices and be issued a FCC user identification and be so labeled.

I. The manufacturer of the building automation system shall provide documentation supporting compliance with ISO-9002 (Model for Quality Assurance in Production, Installation, and Servicing) and ISO-140001 (The application of well-accepted business management principles to the environment). The intent of this specification requirement is to ensure that the products from the manufacturer are delivered through a Quality System and Framework that will assure consistency in the products delivered for this project.

J. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing field panels to current level of technology, and extend new field panels on a previously installed network. Compatibility shall be defined as the ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers or protocol converters.

1.6 Codes and Standards

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
1. National Electric Code (NEC)
2. Uniform Building Code (UBC)
    a. Section 710.5, Wiring in Plenums
    b. Section 1106, Refrigeration Machinery Rooms
    c. Section 1107, Refrigeration Machinery Room Ventilation
    d. Section 1108, Refrigeration Machinery Room Equipment and Controls
3. Uniform Mechanical Code (UMC)
4. ANSI/ASHRAE Standard 135- 2004, BACnet--A Data Communication Protocol for Building Automation and Control Networks.

1.7 System Performance

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
2. Performance. Programmable controllers shall be able to completely execute DDC control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.

1.8 Submittals

A. Product Submittal Requirements. Meet requirements of Section 15010 on Shop Drawings, Product Data, and Samples. Provide six copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been approved for conformity with design intent. Provide drawings as AutoCAD 2015 (or newer) compatible files on optical disk (file format: .dwg, .dxf, .vsd, or comparable) or hard copies on 11" x 17" prints of each drawing. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.

B. Provide submittals within 2 weeks of contract award.

C. Submittal data shall consist of the following:

1. Direct Digital Control System Hardware:
   a. Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
   b. Manufacturer's description and technical data, such as product specification sheets, installation and maintenance instructions for items listed below and for relevant items not listed below:
      1) Direct Digital Controllers (controller panels)
      2) Transducers and transmitters
      3) Sensors (including accuracy data)
      4) Valves
      5) Dampers
      6) Relays and Switches
      7) Control Panels
      8) Power Supplies
      9) Operator Interface Equipment

   c. Wiring diagrams and layouts for each control panel. Show all termination numbers.
   d. Floor plan schematic diagrams indicating control panel and space temperature sensor locations.

2. Central System Hardware and Software:
   a. Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
   b. Manufacturer's description and technical data such as product specifications for items listed below and for relevant items furnished under this contract not listed below:
      1) Central Processing Unit (CPU)
      2) Monitors
      3) Keyboards
      4) Power Supply
      5) Battery Backup
      6) Interface Equipment Between CPU and Control Panels
      7) Operating System Software

8) Operator Interface Software
9) Color Graphic Software
10) Third-Party Software

c. Schematic diagrams of all control, communication, and power wiring for central system installation. Show interface wiring to control system.

d. Provide a list of BMS point naming convention. Indicate the format, structure and standards of typical point names. The naming convention shall follow the Global Campus Building Area Equipment Function" format. Provide a list of point names for typical equipment and functions with specific examples.

3. Controlled Systems:
   a. Riser diagrams showing control network layout, communication protocol, and wire types.
   b. Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
   c. Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic use the same name.
   d. Instrumentation list for each controlled system. List control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
   e. Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system.
   f. Point list for each system controller including both inputs and outputs (I/O), point numbers, controlled device associated with each I/O point, and location of I/O device.

4. Description of process, report formats and checklists to be used in Part 3: "Control System Demonstration and Acceptance."

5. Contractor shall submit documentation in the following phased delivery schedule:
   a. Valve and damper schedules
   b. Point Naming Convention
   c. Sample Graphics
   d. System schematics, including:
      1) System Riser Diagrams
      2) Sequence of Operations
      3) Mechanical Control Schematics
      4) Electrical Wiring Diagrams
      5) Control Panel Layouts
      6) Product Specification Sheets
   e. As-Built drawings

D. Project Record Documents: Submit three copies of record (as-built) documents upon completion of installation. Submittal shall consist of:

1. Project Record Drawings. As-built versions of the submittal shop drawings provided as AutoCAD 2014 (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."

3. Operation and Maintenance (O & M) Manual.

   a. As-built versions of the submittal product data.

b. Names, addresses, and 24-hour telephone numbers of installing contractors and service representatives for equipment and control systems.
c. 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 set points and variables.
d. Programming manual or set of manuals with description of programming language and of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
e. 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.
f. Documentation of all programs created using custom programming language, including set points, tuning parameters, and object database.
g. Graphic files, programs, and database on magnetic or optical media.
h. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware, including computer equipment and sensors.
i. Complete original original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
j. Licenses, guarantees, and warranty documents for equipment and systems.

E. Training Materials. Provide course outline and manuals at least six weeks before training.

1.9 Warranty

A. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Failures on control systems that include all computer equipment, transmission equipment and all sensors and control devices during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

B. 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.

C. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will verify acceptance with Facilities Maintenance Prior to acceptance sign off, sign off by M&O Director. Date of acceptance shall begin warranty period.

D. 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 the above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

E. Exception:

1. 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.

2. Contractor shall not be required to warrant systems, equipment and devices or software if the damages and/or failures were caused by lack of training, unauthorized use, negligence or deliberate action of other parties, or job site conditions.

PART 2 – PRODUCTS

2.1 Materials:

A. All products used in this project installation shall be new and currently manufactured and shall have been applied in similar installations. Do not use this installation as a product test site unless explicitly approved in writing by Owner or Owner's representative. Spare parts shall be available for at least five years after completion of this contract.

2.2 Communication:

A. The design of the BMS shall support networking of operator workstations and Building Controllers. The network architecture shall consist of two levels, an Ethernet based primary network for all operator workstations, servers, and primary DDC controllers along with secondary Floor Level Networks (FLN) for terminal equipment application specific controllers. The Ethernet net work will use the campus backbone whenever possible. Contractor will coordinate with the campus IT personnel to locate and identify proper connections.

B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. Operator Workstation Communication:
1. All color graphic operator workstations shall reside on the Ethernet network and the consoles shall be set up in a client/server configuration.
2. The servers will act as the central database for system graphics and databases to provide consistency throughout all system workstations.
3. The network shall allow concurrent use of multiple BMS software site licenses.

D. Management Level Network Communication (MLN)

1. All PCs shall simultaneously direct connect to the Ethernet Management Level Network without the use of an interposing device.
2. Operator Workstation shall be capable of simultaneous direct connection and communication with BACnet/IP, OPC and TCP/IP corporate level networks without the use of interposing devices.
3. The Management Level Network shall not impose a maximum constraint on the number of operator workstations.
4. Any controller residing on the primary building level networks shall connect to Ethernet network without the use of a PC or a gateway with a hard drive.
5. Any PC on the Management Level Network shall have transparent communication with controllers on the building level networks connected via Ethernet.
6. Any break in Ethernet communication from the PC to the controllers on the building level networks shall result in a notification at the PC.
7. The standard client and server workstations on the Management Level Network shall reside on industry standard Ethernet utilizing standard TCP/IP, IEEE 802.3.
8. System software applications will run as a service to allow communication with Primary Network Controllers without the need for user log in. Closing the

application or logging off shall not prevent the processing of alarms, network status, panel failures, and trend information.

9. Any break in Ethernet communication between the standard client and server workstations on the Management Level Network shall result in a notification at each workstation.
10. Access to the system database shall be available from any standard client workstation on the Management Level Network.

E. Primary Network - Panel to Panel Communication:

1. All Building Controllers shall directly reside on the primary BACnet/IP Ethernet network such that communications may be executed directly between Building Controllers, directly between server and Building Controllers on a peer-to-peer basis.

2. Systems that operate via polled response or other types of protocols that rely on a central processor, file server, or similar device to manage panel-to-panel or device-to-device communications shall not be acceptable.

3. All operator interfaces shall have the ability to access all point status and application report data or execute control functions for any and all other devices. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.

4. The primary network shall use BACnet/IP over Ethernet. All devices must:
   a. Auto-sense 10/100 Mbps networks.
   b. Configured with a Fixed IP Address.
   c. Resolve Name to IP Addresses for devices using a Domain Name Service (DNS) Server on the Ethernet network.
   d. Allow MMI access to an individual Primary Network Controller using industry standard Telnet software to view and edit entire Primary Network.

5. The primary network shall provide the following minimum performance:
   a. Provide high-speed data transfer rates for alarm reporting, report generation from multiple controllers and upload/download efficiency between network devices. System performance shall insure that an alarm occurring at any Building Controller is displayed at any PC workstations, all Building controllers, and other alarm printers within 15 seconds.
   b. Message and alarm buffering to prevent information from being lost.
   c. Error detection, correction, and re-transmission to guarantee data integrity.
   d. Synchronization of real-time clocks between Building Controllers, including automatic daylight savings time corrections.
   e. The primary network shall allow the Building Controllers to access any data from, or send control commands and alarm reports directly to, any other Building Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. Building Controllers shall send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device. The network shall also allow any Building controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
   f. The primary network shall allow the Building Controllers to assign password access and control priorities to each point individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the points

that the operator is authorized for. All other points shall not be displayed at the PC workstation or portable terminal. (e.g. all base building and all tenant points shall be accessible to any base building operators, but only certain base building and tenant points shall be accessible to tenant building operators). Passwords and priorities for every point shall be fully programmable and adjustable.

g. Devices containing custom programming must reside on the Primary Network.

6. Secondary Network – Application Specific Controller Communication:
   a. Communication over the secondary network can be the manufacturer's standard protocol.
   b. Communication over the secondary network must allow BACnet MS/TP protocol.
   c. This level communication shall support a family of application specific controllers for terminal equipment.
   d. The Application Specific Controllers shall communicate bi-directionally with the primary network through Building Controllers for transmission of global data.
   e. A maximum of 30 terminal equipment controllers may be configured on individual secondary network trunks to insure adequate global data and alarm response times.

2.3 Operator Interface:

A. Workstation hardware:

1. Personal computer operator workstations shall be provided for command entry, information management, system monitor, alarm management and database management functions. All real-time control functions shall be resident in the Building Controllers to facilitate greater distribution, fault tolerance and reliability of the building automation control.
   a. Provide workstation(s) of equal capability as located on plans.
   b. Workstation shall consist of a personal computer with minimum 1024MB RAM, hard drive with 160 GB available space, video card with 64 MB RAM capable of supporting a minimum of 1280 × 1024 resolution with a minimum of 32 Bit color, CD-RW, and DVD-ROM Drive, mouse and 101-key enhanced keyboard. Personal computer shall be a Windows XP, or comparable operating system and shall include a minimum 3.0 GHz Pentium processor. Unless minimum campus I.T.S. workstation requirements exceed these specs within 60 days of completion.
   c. The PC monitor shall be of flat panel type and shall support a minimum display resolution of no less than 1280 × 1024 pixels. The display shall have a minimum of 19" visible area in diagonal measurement. Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective.
   d. Provide an HP LaserJet or equivalent printer at each workstation location or on the network (Ethernet) for recording alarms, operator transactions and systems reports.
   e. Provide a color printer for printing of dynamic trend graph report, Excel reports, graphics and any other screen displays. Printer shall include as a minimum Okidata Microline 590 or equivalent.
   f. Alarm Display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message. The alarm display shall provide a mechanism for the operator to sort alarms.

B. Operator Interface Software:

1. Basic Interface Description
   a. Operator interface software shall minimize operator training through the use of user-friendly and interactive graphical applications, 30-character English language point identification, on-line help, and industry standard Windows application software. Interface software shall simultaneously communicate with and share data between Ethernet-connected building level networks.
   b. Provide a graphical user interface that shall minimize the use of keyboard through the use of a mouse or similar pointing device, with a "point and click" approach to menu selection and a “drag and drop” approach to inter-application navigation.
   c. The navigation shall be user friendly by utilizing “forward & back” capability between screens and embedded hyperlinks to open graphics, documents, drawings, etc.
   d. Selection of applications within the operator interface software shall be via a graphical toolbar menu – the application toolbar menu shall have the option to be located in a docked position on any of the four sides of the visible desktop space on the workstation display monitor, and the option to automatically hide itself from the visible monitor workspace when not being actively manipulated by the user.
   e. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. BMS software shall run on a Windows XP, 2000, or comparable 32 bit operating system. System database parameters shall be stored within an object-oriented database. Standard Windows applications shall run simultaneously with the BMS software. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able to work in Microsoft Word, Excel, and other Windows based software packages, while concurrently annunciating on-line BMS alarms and monitoring information.
   f. The software shall provide, as a minimum, the following functionality:
      1) Real-time graphical viewing and control of the BMS environment
      2) Reporting
      3) Scheduling and override of building operations
      4) Collection and analysis of historical data
      5) Point database editing, storage and downloading of controller databases.
      6) Utility for combining points into logical Point Groups. The Point Groups shall then be manipulated in Graphics, trend graphs and reports in order to streamline the navigation and usability of the system.
      7) Alarm reporting, routing, messaging, and acknowledgment
      8) “Collapsible tree,” dynamic system architecture diagram application:
         a) Showing the real-time status and definition details of all workstations and devices on a management level network.
         b) Showing the real-time status and definition details of all Building Controllers at the Primary Network.
         c) Showing the definition details of all application specific controllers
      9) Definition and construction of dynamic color graphic displays.
      10) Online, context-sensitive help, including an index, glossary of terms, and the capability to search help via keyword or phrase.
      11) On-screen access to User Documentation, via online help or PDF-format electronic file.

12) Automatic database backup at the operator interface for database changes initiated at Building Controllers.
13) Display dynamic trend data graphical plot.
    a) Must be able to run multiple plots simultaneously
    b) Each plot must be capable of supporting 10 pts/plot minimum
    c) Must be able to command points directly off dynamic trend plot application.
    d) Must be able to plot both real-time and historical trend data
14) Program editing
15) Transfer trend data to 3rd party spreadsheet software
    a) Scheduling reports
    b) Operator Activity Log
    c) Open communications via OPC ServeOpen communications via BACnet Client & Server

g. Enhanced Functionality:
1) Provide functionality such that any of the following may be performed simultaneously on-line, and in any combination, via adjustable user-sized windows. Operator shall be able to drag and drop information between the following applications, reducing the number of steps to perform a desired function (e.g., Click on a point on the alarm screen and drag it to the dynamic trend graph application to initiate a dynamic trend on the desired point):
    a) Dynamic color graphics application
    b) Alarm management application
    c) Scheduling application
    d) Dynamic trend graph data plotter application
    e) Dynamic system architecture diagram application
    f) Control Program and Point database editing applications
    g) Reporting applications
2) Report and alarm printing shall be accomplished via Windows Print Manager, allowing use of network printers.

h. Security: Operator-specific password access protection shall be provided to allow the administrator/manager to limit users' workstation control, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. Operator privileges shall "follow" the operator to any workstation logged onto (up to 999 user accounts shall be supported). The administrator or manager shall be able to grant discrete levels of access and privileges, per user, for each point, graphic, report, schedule, and BMS workstation application. And each BMS workstation user account shall use a Windows Operating System user account as a foundation.

i. The operator interface software shall also include an application to track the actions of each individual operator, such as alarm acknowledgement, point commanding, schedule overriding, database editing, and logon/logoff. The application shall list each of the actions in a tabular format, and shall have sorting capabilities based on parameters such as ascending or descending time of the action, or name of the object on which the action was performed. The application shall also allow querying based on object name, operator, action, or time range.

j. Dynamic Color Graphics application shall include the following:
1) Must include graphic editing and modifying capabilities
2) A library of standard control application graphics and symbols must be included
3) Must be able to command points directly off graphics application

4) Graphic display shall include the ability to depict real-time point values dynamically with animation, picture/frame control, symbol association, or dynamic informational text-blocks
5) Navigation through various graphic screens shall be optionally achieved through a hierarchical “tree” structure
6) Graphics viewing shall include zoom capabilities
7) Graphics shall be capable of displaying the status of points that have been overridden by a field HAND switch, for points that have been designed to provide a field HAND override capability.
8) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

k. Reports shall be generated on demand or via pre-defined schedule, and directed to CRT displays, printers or file. As a minimum, the system shall allow the user to easily obtain the following types of reports:
1) A general listing of all or selected points in the network
2) List of all points currently in alarm
3) List of all points currently in override status
4) List of all disabled points
5) List of all points currently locked out
6) List of user accounts and access levels
7) List all weekly schedules and events
8) List of holiday programming
9) List of control limits and deadbands
10) Custom reports from 3rd party software
11) System diagnostic reports including, list of Building panels on line and communicating, status of all Building terminal unit device points
12) List of programs
13) List of point definitions
14) List of logical point groups
15) List of alarm strategy definitions
16) List of Building Control panels
17) Point totalization report
18) Point Trend data listings
19) Initial Values report
20) User activity report

l. Scheduling and override
1) Provide a calendar type format for simplification of time and date scheduling and overrides of building operations. Schedule definitions reside in the PC workstation and in the Building Controller to ensure time equipment scheduling when PC is off-line, PC is not required to execute time scheduling. Provide override access through menu selection, graphical mouse action or function key. Provide the following capabilities as a minimum:
a) Weekly schedules
b) Zone schedules
c) Event schedules – an event consists of logical combinations of equipment and/or zones
d) Report schedules
e) Ability to schedule for a minimum of up to ten (10) years in advance.
2) Additionally, the scheduling application shall:

a) Provide filtering capabilities of schedules, based on name, time, frequency, and schedule type (event, zone, report)
b) Provide sorting capabilities of schedules, based on name, time and type of schedule (zone, event, report)
c) Provide searching capabilities of schedules based on name – with wildcarding options

m. Collection and Analysis of Historical Data
1) Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals (up to four time-based definitions per point) or change of value, both of which shall be user-definable. Trend data shall be collected stored on hard disk for future diagnostics and reporting. Automatic Trend collection may be scheduled at regular intervals through the same scheduling interface as used for scheduling of zones, events, and reports. Additionally, trend data may be archived to network drives or removable disk media for future retrieval.
2) Trend data reports shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or predefined groups of selected points. Provide additional functionality to allow predefined groups of up to 250 trended points to be easily transferred on-line to Microsoft Excel. BMS contractor shall provide custom designed spreadsheet reports for use by the owner to track energy usage and cost, equipment run times, equipment efficiency, and/or building environmental conditions. BMS contractor shall provide setup of custom reports including creation of data format templates for monthly or weekly reports.
3) Provide additional functionality that allows the user to view real-time trend data on trend graphical plot displays. A minimum of ten points may be plotted, of either real-time or historical data. The dynamic graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the display and take "snapshots" of plot screens to be stored on the workstation disk for future recall and analysis. Exact point values may be viewed and the graphs may be printed. A minimum of ten (10) dynamic graphs shall run simultaneously. Operator shall be able to command points directly on the trend plot by double clicking on the point. Operator shall be able to zoom in on a specific time range within a plot. The dynamic trend plotting application shall support the following types of graphs, with option to graph in 3D: line graph, area graph, curve graph, area-curve graph, step graph, and scatter graph. Each graph may be customized by the user, for graph type, graph text, titles, line styles and weight, colors, and configurable x- and y-axes.

n. Dynamic Color Graphic Displays
1) Capability to create color graphic floor plan displays and system schematics for each piece of mechanical equipment, including, but not limited to, air handling units, chilled water systems, hot water boiler systems, and room level terminal units.
2) The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based

commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.

3) Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics or graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
   a) Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the operator interface software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed.
   b) Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
   c) Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
   d) Equipment state or values can be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
   e) State text for digital points can be user-defined up to eight characters.
4) Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
5) Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), Internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.
6) The Windows environment of the PC operator workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
7) Off the shelf graphic software shall be provided to allow the user to add, modify or delete system graphic background displays.
8) A clipart library of HVAC application and automation symbols shall be provided including fans, valves, motors, chillers, AHU systems, standard ductwork diagrams and laboratory symbols. The user shall have the ability to add custom symbols to the clipart library. The clipart library shall include a minimum of 400 application symbols. In addition, a library consisting of a minimum of 700 graphic background templates shall be provided.
9) The Graphics application shall include a set of standard Terminal Equipment controller application-specific background graphic templates. Templates shall provide the automatic display of a

selected Terminal Equipment controller's control values and parameters, without the need to create separate and individual graphic files for each controller.

o. System Configuration & Definition

1) A "Collapsible tree," dynamic system architecture diagram/display application of the site-specific BMS architecture showing status of controllers, PC workstations and networks shall be provided. This application shall include the ability to add and configure workstations, Building Controllers, as well as 3rd-party integrated components. Symbols/Icons representing the system architecture components shall be user-configurable and customizable, and a library of customized icons representing 3rd-party integration solutions shall be included. This application shall also include the functionality for real-time display, configuration and diagnostics connections to Building Controllers.

2) Network wide control strategies shall not be restricted to a single Building Controller, but shall be able to include data from any and all other network panels to allow the development of Global control strategies.

3) Provide automatic backup and restore of all Building controller databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Building Controller. Changes made at the user-interface of Building Controllers shall be automatically uploaded to the workstation, ensuring system continuity.

4) System configuration, programming, editing, graphics generation shall be performed on-line.

5) Point database configuration shall be available to the user within a dedicated point database editor application included in the operator interface software. The editor shall allow the user to create, view existing, modify, copy, and delete points from the database.

6) The point editor shall have the capability to assign "informational text" to points as necessary to provide critical information about the equipment.

7) The point editor shall also allow the user to configure the alarm management strategy for each point. The editor shall provide the option for editing the point database in an online or offline mode with the Building Controllers.

8) The operator interface software shall also provide the capability to perform bulk modification of point definition attributes to a single or multiple user-selected points. This function shall allow the user to choose the properties to copy from a selected point to another point or set of points. The selectable attributes shall include, but are not limited to, Alarm management definitions and Trend definitions.

9) Control program configuration shall be available to the user within a dedicated control program editor application included in the operator interface software. The editor shall allow for creation, modification and deletion of control programs. The editor shall include a programming assistance feature that interactively guides the user through parameters required to generate a control program. The editor shall also include the ability to automatically compile the program to ensure its compatibility with the Building Controllers. The editor shall

provide the option for editing the control programs in an online or offline mode, and also the ability to selectively enable or disable the live program execution within the Building Controllers.

p. Alarm Management

1) Alarm Routing shall allow the user to send alarm notification to selected printers or workstation location(s) based on time of day, alarm severity, or point type.
2) Alarm Notification shall be presented to each workstation in a tabular format application, and shall include the following information for each alarm point: name, value, alarm time & date, alarm status, priority, acknowledgement information, and alarm count. Each alarm point or priority shall have the ability to sound a discrete audible notification.
3) Alarm Display shall have the ability to list & sort the alarms based on alarm status, point name, ascending or descending alarm time.
4) Directly from the Alarm Display, the user shall have the ability to acknowledge, silence the alarm sound, print, or erase each alarm. The interface shall also have the option to inhibit the erasing of active acknowledged alarms, until they have returned to normal status. The user shall also have the ability to command, launch an associated graphic or trended graphical plot, or run a report on a selected alarm point directly on the Alarm Display.
5) Each alarm point shall have a direct link from the Alarm Display to further user-defined point informational data. The user shall have the ability to also associate real-time electronic annotations or notes to each alarm.
6) Alarm messages shall be customizable for each point, or each alarm priority level, to display detailed instructions to the user regarding actions to take in the event of an alarm. Alarm messages shall also have the optional ability to individually enunciate on the workstation display via a separate pop-up window, automatically being generated as the associated alarm condition occurs. The system shall have the ability to modify the priority text based on operator preference.
7) Alarm Display application shall allow workstation operators to send and receive real-time messages to each other, for purposes of coordinating Alarm and BMS system management.

C. PORTABLE OPERATOR'S TERMINAL (POT)

1. Provide Notebook style industry standard, commercially available portable operator terminals with a LCD display and a full-featured keyboard. When shown on contract drawings. The POT shall be handheld and plug directly into all Building Controllers as described below. Provide a user-friendly, English language-prompted interface for quick access to system information, not codes requiring look-up charts. Siemens *Datamate*™ software shall be provided to meet this requirement.

2. Functionality of the portable operator's terminal connected at any Building Controller:

a. Access all Building Controllers and Application Specific Controllers (ASCs) on the network.
b. Backup and/or restore Building Controller data bases for all system panels, not just the Building Controller connected to.
c. Display all point, selected point and alarm point summaries.

d. Display trending and totalization information.
e. Add, modify and/or delete any existing or new system point.
f. Command, change, and enable/disable any system point.
g. Program and load custom control sequences as well as standard energy management programs.
h. Acknowledge alarms.

3. Functionality of the portable operator's terminal connected to any application specific controller:
   a. Provide connection capability at either the Floor Level Network Controller or a related room sensor to access controller information.
   b. Provide status, setup and control reports.
   c. Modify, select and store controller data base.
   d. Command, change, and enable/disable any controller point.

4. Connection of a POT to a Building or ASC Controller shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.

5. Portable operator terminal access to controller shall be password-controlled. Password protection shall be configurable for each operator based on function, points (designating areas of the facility), and edit/view capability.

2.4 Building Controller Software

A. General:

1. The applications software shall match Campus existing control system.

2. Furnish the following applications software to form a complete operating system for building and energy management as described in this specification.

3. The software programs specified in this Section shall be provided as an integral part of Building Controllers and shall not be dependent upon any higher level computer or another controller for execution.

4. All points, panels and programs shall be identified by a 30 character name. All points shall also be identified by a 16 character point descriptor. The same names shall be displayed at both Building Controller and the Operator Interface.

5. All digital points shall have a user defined two-state status indication with 8 characters minimum (e.g. Summer, Enabled, Disabled, Abnormal).

6. The Building Controller Software shall be capable of BACnet communications. The BACnet Building Controller (B-BC) shall have demonstrated interoperability during at least one BTL Interoperability Workshop and shall substantially conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, Annex L.

7. Building Controllers shall have the ability to perform energy management routines including but not limited to time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

8. The Building Controllers shall have the ability to perform the following pre tested control algorithms:

a. Two position control
b. Proportional control
c. Proportional plus integral control
d. Proportional, integral, plus derivative control
e. Automatic tuning of control loops
f. Model-Free Adaptive Control

9. Each controller shall be provided with an interactive HELP function to assist operators using POTs and remote connected operators.

10. Building Controllers shall not be susceptible` to Microsoft Windows operating systems based viruses.

B. System Security

1. User access shall be secured using individual security passwords and user names.

2. Passwords shall restrict the user to the objects, applications, and system functions as assigned by the system manager.

3. User Log On / Log Off attempts shall be recorded.

4. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user-definable.

5. Use of workstation resident security as the only means of access control is not an acceptable alternative to resident system security in the field panel.

C. User Defined Control Applications:

1. Controllers shall be able to execute custom, job-specific processes defined by the user, to automatically perform calculations and special control routines.

2. It shall be possible to use any system measured point data or status, any system calculated data, a result from any process, or any user-defined constant in any controller in the system.

3. Any process shall be able to issue commands to points in any and all other controllers in the system.

4. Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

5. Each controller shall support plain language text comment lines in the operating program to allow for quick troubleshooting, documentation, and historical summaries of program development.

6. Controller shall provide a HELP function key, providing enhanced context sensitive on-line help with task oriented information from the user manual.

D. Alarm Management:

1. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each Building Controller shall perform distributed, independent alarm analysis, minimize network traffic and prevent alarms from being lost. At no time shall the Building Controllers ability to report alarms be affected by either

operator or activity at a PC workstation, local I/O device or communications with other panels on the network

2. Conditional alarming shall allow generation of alarms based upon user defined multiple criteria.

3. An Alarm “shelving” feature shall be provided to disable alarms during testing. (Pull the Plug, etc.).

4. Binary Alarms. Each binary object shall be set to alarm based on the operator-specified state. Provide the capability to automatically and manually disable alarming.

5. Analog Alarms. Each analog object shall have both high and low alarm limits. Alarming must be able to be automatically and manually disabled.

6. All alarm or point change reports shall include the point's user defined language description and the time and date of occurrence.

7. Alarm reports and messages shall be routed to user-defined list of operator workstations, or other devices based on time and other conditions. An alarm shall be able to start programs, print, be logged in the event log, generate custom messages, and display graphics.

8. In addition to the point's descriptor and the time and date, the user shall be able to print, display or store a 200 character alarm message to more fully describe the alarm condition or direct operator response.

9. Each Building Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

E. Scheduling:

1. Provide a comprehensive menu driven program to automatically start and stop designated multiple objects or events in the system according to a stored time

2. Schedules shall reside in the building controller and shall not rely on external processing or network.

3. It shall be possible to define a group of objects as a custom event (i.e. meeting, athletic activity, etc.). Events can then be scheduled to operate all necessary equipment automatically.

4. For points assigned to one common load group, it shall be possible to assign variable time delays between each successive start and/or stop within that group.

5. The operator shall be able to define the following information:
   a. Time, day
   b. Commands such as on, off, auto, etc.
   c. Time delays between successive commands.
   d. There shall be provisions for manual overriding of each schedule by an authorized operator.

6. It shall be possible to schedule calendar-based events up to one year in advance based on the following:
   a. Weekly Schedule. Provide separate schedules for each day of the week. Each of these schedules should include the capability for start, stop, optimal start, optimal stop, and night economizer. When a group of

objects are scheduled together as an Event, provide the capability to adjust the start and stop times for each member.

b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by the standard schedule for that day of the week.

7. Automatic Daylight Savings Time Switchover: The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

8. Night setback control. The system shall provide the ability to automatically adjust setpoints for night control.

9. Loop Control. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.

10. Sequencing. Provide application software based upon the sequences of operation specified to properly sequence equipment.

11. Staggered Start:
    a. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.
    b. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

12. Totalization:
    a. Run-Time Totalization. Building Controllers shall automatically accumulate and store run-time hours for all digital input and output points. A high runtime alarm shall be assigned, if required, by the operator.
    b. Consumption totalization. Building Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.
    c. Event totalization. Building Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly or monthly basis for all points. The event totalization feature shall be able to store the records associated with events before reset.

13. Data Collection:
    a. A variety of historical data collection utilities shall be provided to manually or automatically sample, store, and display system data for all points.
    b. Building Controllers shall store point history data for selected analog and digital inputs and outputs:
        1) Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each Building Controllers point group.
    c. Trend data shall be stored at the Building Controllers and uploaded to the workstation when retrieval is desired. Uploads shall occur based upon either user-defined interval, manual command or when the trend buffers

are full. All trend data shall be available for use in 3rd party personal computer applications.

d. Loop Tuning. Building Controllers shall also provide high resolution sampling capability for verification of DDC control loop performance. Documented evidence of tuned control loop performance shall be provided on a <monthly, seasonal, quarterly, annual> period.

1) For Model-Free Adaptive Control loops, evidence of tuned control loop performance shall be provided via graphical plots or trended data logs. Graphical plots shall minimally include depictions of setpoint, process variable (output), and control variable (e.g., temperature). Other parameters that may influence loop control shall also be included in the plot (e.g., fan on/off, mixed-air temp).

2) For PID control loops, operator-initiated automatic and manual loop tuning algorithms shall be provided for all operator-selected PID control loops. Evidence of tuned control loop performance shall be provided via graphical plots or trended data logs for all loops.

a) In automatic mode, the controller shall perform a step response test with a minimum one-second resolution, evaluate the trend data, calculate the new PID gains and input these values into the selected LOOP statement.

b) Loop tuning shall be capable of being initiated either locally at the Building Controller, from a network workstation or remotely using dial-in modems. For all loop tuning functions, access shall be limited to authorized personnel through password protection.

2.5 Building Controllers

A. Building Controllers shall be 32 bit, multi-tasking, multi-user, real-time 48 MHz digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the attached point list.

B. Each Building Controller shall support a minimum of 3 directly connected Secondary Networks.

C. Each Building Controller shall have sufficient memory, a minimum of 72 megabyte, to support its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, and dial-up communications.

D. Building Controller shall have an integral real-time clock.

E. Each Building Controller shall support firmware upgrades without the need to change hardware.

F. Each Building Controller shall support:

1. Monitoring of industry standard analog and digital inputs, without the addition of equipment outside the Building Controller cabinet.

2. Monitoring of industry standard analog and digital outputs, without the addition of equipment outside the Building Controller cabinet.

G. Spare Point Capacity. Each Building Controller shall have a minimum of 10 percent spare point capacity.

1. The type of spares shall be in the same proportion as the implemented I/O functions of the panel, but in no case shall there be less than one spare of each implemented I/O type.

2. Provide all processors, power supplies, and communication controllers so that the implementation of adding a point to the spare point location only requires the addition of the appropriate:
   a. Expansion modules
   b. Sensor/actuator
   c. Field wiring/tubing.

H. Serial Communication. Building Controllers shall provide at least two EIA-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, and portable laptop operator's terminals. Building Controllers shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.

I. Manual Override. The operator shall have the ability to manually override automatic or centrally executed commands at the Building Controller via local, point discrete, integral hand/off/auto operator override switches for all digital control type points and gradual switches for all analog control type points. These override switches shall be operable whether the panel processor is operational or not. Each Building Controller shall monitor and alarm the hand, off and auto positions of integral HOA switches.

J. I/O Status and Indication. Building Controllers shall provide local LED status indication for each digital input and output for constant, up-to-date verification of all point conditions without the need for an operator I/O device. Graduated intensity LEDs or analog indication of value shall also be provided for each analog output. All wiring connections shall be made to field-removable terminals.

K. Self Diagnostics. Each Building Controller shall continuously perform self diagnostics, communication diagnosis, and diagnosis of all panel components. The Building Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication for any system.

L. Power loss. In the event of the loss of power, there shall be an orderly shutdown of all Building Controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 100 hours.

M. Environment

1. Controller hardware shall be suitable for the anticipated ambient conditions.

2. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

3. Controllers used in conditioned space shall be mounted in dust-proof enclosures and shall be rated for operation at 0°C to 49°C (32°F to 120°F).

N. Immunity to power and noise.

1. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage.

2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

3. Isolation shall be provided at all primary network terminations, as well as all field point terminations to suppress induced voltage transients consistent with:
   a. RF-Conducted Immunity (RFCI) per ENV 50141 (IEC 1000-4-6) at 3 V.
   b. Electro Static Discharge (ESD) Immunity per EN 61000-4-2 (IEC 1000-4-2) at 8 kV air discharge, 4 kV contact
   c. Electrical Fast Transient (EFT) per EN 61000-4-4 (IEC 1000-4-4) at 500 V signal, 1 kV power
   d. Output Circuit Transients per UL 864 (2,400V, 10A, 1.2 Joule max)

4. Isolation shall be provided at all Building Controller's AC input terminals to suppress induced voltage transients consistent with:
   a. IEEE Standard 587 1980
   b. UL 864 Supply Line Transients
   c. Voltage Sags, Surge, and Dropout per EN 61000-4-11 (EN 1000-4-11)

O. Minimum Approved Building Controllers. BMS Contractors shall furnish Building Controllers as listed below. Providing an approved controller does not release the contractor from meeting all performance, software and hardware specifications for Building Controllers and system operations.
   1. Siemens Building Technologies Inc. - Modular Building/Equipment Controllers (MBC/MEC).

2.6 Application Specific Controllers (ASC)

A. General:

1. Provide for control of each piece of equipment , including, but not limited to the following:
   a. Boilers
   b. Pumps

B. Each Building Controller shall be able to communicate with application specific controllers (ASCs) over the Secondary Network to control terminal equipment only.

C. The use of Secondary Network controllers with custom program applications to control AHU's, water systems, etc. is not acceptable.

D. Each ASC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each ASC shall be a microprocessor-based, multi-tasking, real-time digital control processor.

E. Each ASC shall include all point inputs and outputs necessary to perform the specified control sequences. The ASC shall accept input and provide output signals that comply with industry standards. Controllers utilizing proprietary control signals shall not be acceptable. Outputs utilized either for two-state, modulating floating, or proportional control, allowing for additional system flexibility.

F. Space Temperature Sensors. Each controller performing space temperature control shall be provided with a matching room temperature sensor.
   1. Wired Sensor specifications. The sensor may be either RTD or thermistor type providing the following.

a. Accuracy: + .5 F
b. Operating Range: 35 to 115 F
c. Set Point Adjustment Range: 55 to 95 F
d. Calibration Adjustments: None required
e. Installation: Up to 100 ft. from controller
f. Auxiliary Communications Port:
1) Local LCD Temperature Display: as required
2) Set Point Adjustment Dial: as required
3) Occupancy Override Switch: as required

2. Wireless Space Temperature Sensors specifications. The sensor shall be 100K Ohm Thermistor or equivalent type providing the following.
a. Accuracy: + .5 F
b. Operating Range: 35 to 95 F
c. Monitoring Range: 55 to 95 F
d. Calibration Adjustments: None required
e. Installation: Up to 100 ft. from controller
f. Battery life: Minimum 3 years
g. Auxiliary Communications Port: as required

3. Set Point Modes:
a. Independent Heating, Cooling
b. Night Setback-Heating
c. Night Setback-Cooling

4. Auxiliary Communication Port. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

5. Set Point Adjustment Dial. The set point adjustment dial shall allow for modification of the temperature by the building operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two-line display, or via the portable operator's terminal.

6. Override Switch. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two-line display or via the portable operator's terminal.

G. Communication. Each controller shall perform its primary control function independent of other Secondary Network communication, or if Secondary Network communication is interrupted. Reversion to a fail-safe mode of operation during Secondary Network interruption is not acceptable.

H. Control Algorithms. The controller shall receive its real-time data from the Building Controller time clock to insure Secondary Network continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via room sensor LCD or the portable operator's terminal as specified herein. Controllers that incorporate proportional and integral (PI) control algorithms only shall not be acceptable.

I. Control Applications. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

J. Calibration. Each controller shall include provisions for manual and automatic calibration of the differential pressure transducer in order to maintain stable control and insuring against drift over time.
   1. Manual calibration may be accomplished by either commanding the actuator to 0% via the POT or by depressing the room sensor override switch. Calibration of the transducer at the controller location shall not be necessary
   2. Calibration shall be accomplished by stroking the terminal unit damper actuator to a 0% position so that a 0 CFM air volume reading is sensed. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.
   3. Calibration shall be accomplished by zeroing out the pressure sensor and holding damper at last known position until calibration is complete. The controller shall automatically accomplish this whenever the system mode switches from occupied to unoccupied or vice versa.

K. Memory.
   1. Provide each ASC with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or minimum of 72-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration.
   2. Upon replacement, new ASCs shall recover control function and site specific defaults automatically and resume normal operation

L. Power Supply. The ASCs shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC, allowing for power source fluctuations and voltage drops. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type. The BMS contractor shall provide 24 VAC power to the terminal units by utilizing:
   1. The existing line voltage power trunk and installing separate isolation transformers for each controller
   2. Dedicated line voltage power source and isolation transformers at a central location and installing 24VAC power trunk to supply multiple ASCs in the area.

M. Environment. The controllers shall function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 95%RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the circuit board assembly.

N. Immunity to noise. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

O. Manufacturer Installed Controls.
   1. BMS manufacturer shall furnish ASC and actuator for factory mounting to equipment manufacturer.
   2. Cost of factory mounting shall be borne by equipment manufacturer.
   3. For VAV terminals, equipment manufacturer shall provide and install flow-cross sensor, 24 Vac transformer, controls enclosure, fan relay, SCR and factory install, wire and tube the ASC controller and actuator provided by Siemens.

P. Controllers for VAV terminals.
   1. All VAV terminal control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. ASC's that require factory application changes are not acceptable. The VAV terminal ASC shall support the following types of pressure independent terminal boxes as a minimum:
      a. VAV cooling only
      b. VAV with hot water or electric reheat
      c. Fan-powered VAV

d. Fan-powered VAV with hot water or electric reheat

2. The controller shall include a differential pressure transducer that shall connect to the terminal unit manufacturer's standard averaging air velocity sensor to measure the average differential pressure in the duct. The controller shall convert this value to actual air flow. Single point air velocity sensing is not acceptable. The differential pressure transducer shall have a measurement range of 0 to 4000 fpm (0 to 20.4 m/s) and measurement accuracy of +5% at 400 to 4000 fpm (2 to 20 m/s), insuring primary air flow conditions shall be controlled and maintained to within +5% of Set point at the specified parameters. The BMS contractor shall provide the velocity sensor if required to meet the specified functionality.

Q. Controllers for CV terminals.

1. Constant volume ASCs shall meet all requirements of paragraphs as previously specified for VAV terminals. The controllers shall have a minimum and maximum flow set point, which shall be selected based on interior ventilation requirements. Under normal conditions, the set point shall be set to minimum set point. When the floor area requires additional ventilation (high CO2 level, manual command, etc.) the set point shall be set to maximum set point.

2.7 Input/Output Interface:

A. Hardwired inputs and outputs may tie into the system through building or application specific controllers.

B. All input points and output points shall be protected such that shorting of the point to itself, to another point, or to ground will cause no damage to the controller. All input and output points shall be protected from voltage up to 24 V of any duration, such that contact with this voltage will cause no damage to the controller.

C. Binary inputs shall allow the monitoring of On/Off signals from remote devices. The binary inputs shall provide a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against the effects of contact bounce and noise. Binary inputs shall sense “dry contact” closure without external power (other than that provided by the controller) being applied.

D. Pulse accumulation input objects. This type of object shall conform to all the requirements of binary input objects and also accept up to 10 pulses per second for pulse accumulation.

E. Analog inputs shall allow the monitoring of low-voltage (0 to 10 VDC), current (4 to 20 mA), or resistance signals (thermistor, RTD). Analog inputs shall be compatible with—and field configurable to— commonly available sensing devices.

F. Binary outputs shall provide for On/Off operation or a pulsed low-voltage signal for pulse width modulation control. Binary outputs on building and custom application controllers shall have three-position (On/Off/Auto) override switches and status lights. Outputs shall be selectable for either normally open or normally closed operation.

G. Analog outputs shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10 VDC, 4 to 20 mA or 0-20 PSI signal as required to provide proper control of the output device. Analog outputs on building or custom application controllers shall have status lights and a two-position (AUTO/MANUAL) switch and manually adjustable potentiometer for manual override. Analog outputs shall not exhibit a drift of greater than 0.4% of range per year.

H. Tri-State Outputs. Provide tri-state outputs (two coordinated binary outputs) for control of three-point floating type electronic actuators without feedback. Use of three-point floating devices shall be limited to zone control and terminal unit control applications (VAV

terminal units, duct-mounted heating coils, zone dampers, radiation, etc.). Control algorithms shall run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.

I. System Object Capacity. The system size shall be expandable to at least twice the number of input/ output objects required for this project. Additional controllers (along with associated devices and wiring) shall be all that is necessary to achieve this capacity requirement. The operator interfaces installed for this project shall not require any hardware additions or software revisions in order to expand the system.

2.8 Power Supplies and Line Filtering

A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

B. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
   1. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
   2. Line voltage units shall be UL recognized and CSA approved.

C. Power line filtering.
   1. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
      a. Dielectric strength of 1000 volts minimum
      b. Response time of 10 nanoseconds or less
      c. Transverse mode noise attenuation of 65 dB or greater
      d. Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz.

2.9 Auxiliary Control Device

A. GENERAL
   1. Specified in this section are the following hard wired input/output devices connected to the Building Controller or ASC. Devices only required if specified by points list , control diagram or sequence of operation.
      a. Electric Damper Actuators
      b. Motorized Isolation Valves
      c. Ball Valves
      d. Automatic Control Valves
      e. Airflow Measuring Stations
      f. Binary Temperature Devices
      g. Temperature Sensors
      h. Dew Point/Humidity Sensors
      i. Pressure Sensors
      j. Water Differential Pressure Sensors
      k. Differential Pressure Switches
      l. Analog Water Level Sensors
      m. Water Leak Detection Systems
      n. Audio/Visual Alarm Units
      o. Fuel Oil Meters
      p. Water BTU Meters
      q. Vortex Shedding Flow Meters

r. Indoor Air Quality (CO2/VOC) Space Sensors
s. Relays
t. Override Timers
u. Current Transformers
v. Voltage Transmitters
w. Voltage Transformers
x. Power Monitors
y. Current Switches
z. Pressure Electric Switches
aa. Electro-pneumatic Transducers
bb. Local Control panels
cc. Local User Display

B. MOTORIZED ISOLATION VALVES

1. Butterfly Valves
   a. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein. All butterfly valves shall have body ratings in accordance with the piping specifications. Valves shall be high performance, fully lugged with carbon steel body ANSI 150/300. Valves shall be rated for bubble tight dead end closure, with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat and seals.
   b. Motorized valves located outdoors or in areas subject to outdoor air conditions provide fail in place, electric operators with water proof enclosure, crankcase heater, and open and closed position limit switches. Valve and all accessories shall be constructed for outdoor use. All electrical devices shall be weather proof and NEMA 4 rated.
   c. All valves shall be provided with external position indicators and a speed control device to prevent to rapid closure.
   d. All valves shall be provided with manual override hand wheels for operating the valve.
   e. The valves shall be line size as shown on plans.
   f. Motorized isolation valves shall be Keystone, Bray, Jamesbury 815/830L, Fisher, or DeZurik Model HP II.

2. BALL VALVES.
   a. Furnish automatic full port ball valves for isolation requirements on line sizes up to 2'as shown on the drawings or required herein. All ball valves shall have ANSI 250 body rating. Valves shall bronze body and stainless steel trim.
   b. Valves shall close against a differential pressure equal to the design pump head pressure plus 10%.
   c. The valves shall fail to their safe position upon power loss as specified in the sequence of operation.
   d. All valves shall be provided with manual override.
   e. Provide valve position indicator end switches with the actuator.
   f. The valves shall be line size as shown on plans.
   g. Motorized isolation valves shall be, Siemens, Dezurik or Neptronic.

3. AUTOMATIC CONTROL VALVES.
   a. General:
      1) Control valves shall be two-way or three-way type single seated globe type for two-position or modulating service as shown. Valves shall meet ANSI Class IV leakage rating.
      2) Body pressure rating and connection type construction shall conform to pipe, fitting and valve schedules. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided.

3) Valve operators shall be of pneumatic or electric type.
4) The valves shall be quiet in operation and fail-safe in either normally open or normally closed position in the event of power failure.
5) Control valve operators shall be sized to close against a differential pressure equal to the design pump head plus 10 percent.
6) Furnish differential pressure control valves for all water systems as shown on plans and/or specified in the sequence of operations.
7) Provide valves 2" and smaller with screwed end bronze bodies and stainless steel trim. Provide valves 2-1/2" and larger with flanged ends, cast iron body and stainless steel trim.
8) For modulating service that require large valve size (above 6”), such as cooling tower temperature bypass, chiller head pressure ,etc. where proper control with globe type control valve cannot be achieved or the application is not economical butterfly or v-port ball valves are allowed.

b. Water Valves:
1) Control valves shall be of equal percentage flow characteristics for modulating service.
2) Steam Valves:
3) Control valves shall be of linear flow characteristics for modulating service.

C. BINARY TEMPERATURE DEVICES

1. Line-voltage space thermostat:
a. Line-voltage thermostats shall be bimetal-actuated, snap acting SPDT contact, enclosed, UL listed for electrical rating. The thermostat cover shall provide exposed set point adjustment knob. The thermostat shall operate within the 55°F to 85°F setpoint range, with 2°F maximum differential.

2. Low-temperature safety thermostat:
3. Low-limit air stream thermostats shall be UL listed, vapor pressure type, with a sensing element of 20 ft. minimum length. Element shall respond to the lowest temperature sensed by any 1 ft. section. The low-limit thermostat shall be automatic reset, SPDT type.

4. Aquastat:
a. Strap-on type thermostats shall be provided for low or high temperature limit service on hot water or steam condensate pipes. The thermostats shall be UL listed, with a liquid-filled bulb type sensing element and capillary tubing. The thermostat shall operate within the 20°F to 120°F, or 100°F to 240°F, setpoint range, with an adjustable 6°F differential.
b. The low-limit thermostat shall be automatic reset, snap acting SPDT type with concealed set point adjustment.

D. TEMPERATURE SENSORS

1. Provide the following instrumentation as required by the monitoring, control and optimization functions. All temperature sensor shall use platinum RTD elements only, nickel or silicon are not acceptable. All control signals shall be via a 4-20 mA loop.

2. Room Temperature:
a. Temperature monitoring range: -40/+240 F
b. Output signal: 1000Ω RTD Resistance

c. Installation adjustments: none required
d. Element: Platinum
e. Factory calibration point: 32 deg F
f. Accuracy at calibration point: +0.1% at 32F

3. Liquid Immersion Temperature
a. Temperature monitoring range: -40/+240 F
b. Output signal: 1000Ω RTD Resistance
c. Installation adjustments: none required
d. Element: Platinum
e. Factory calibration point: 32 deg F
f. Accuracy at calibration point: +0.1% at 32F

4. Duct (Single Point) Temperature
a. Temperature monitoring range: -40/+240 F
b. Output signal: 1000Ω RTD Resistance
c. Installation adjustments: none required
d. Element: Platinum
e. Factory calibration point: 32 deg F
f. Accuracy at calibration point: +0.1% at 32F

5. Duct (Averaging) Temperature
a. Temperature monitoring range: -40/+240 F
b. Output signal: 1000Ω RTD Resistance
c. Installation adjustments: none required
d. Element: Platinum
e. Factory calibration point: 32 deg F
f. Accuracy at calibration point: +0.1% at 32F

6. Outside Air Temperature
a. Temperature monitoring range: -40/+240 F
b. Output signal: 1000Ω RTD Resistance
c. Installation adjustments: none required
d. Element: Platinum
e. Factory calibration point: 32 deg F
f. Accuracy at calibration point: +0.1% at 32F

E. PRESSURE SENSORS

1. Air Static Pressure Sensor
a. Duct Static range: -.5 to + 7.5"wg
b. Accuracy: + .05" w.g.
c. Output signal: 4 - 20 mA
d. Actual sensor used will be sized for its application so that it is accurate in the range it will be reading. (e.g. room -0.5- +0.5, fan static pressure 0-5.0", etc.)

F. WATER DIFFERENTIAL PRESSURE SENSOR

1. Transducer shall have linear output signal. Zero and span shall be field adjustable.

2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure up to 250 psig without damage.

3. Water pressure transducer shall have stainless steel diaphragm construction with elastomer seals. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.

4. Provide NEMA 4 construction differential pressure sensors for all differential pressure sensors and bypass valves. Sensor shall be factory calibrated for operating range and rated for system pressure. Provide manufacturers standard 3 valve manifold . Output shall be 4-20 ma. Sensor shall be Setra model 230 with 3 port manifold or approved equal.

G. ANALOG WATER LEVEL SENSORS

1. Furnish and install full height, analog level sensors for each location as specified in points list. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required. Sensor shall be Drexel Brook, Gems or equal.

H. WATER METERS

1. Provide ultra sonic water flow meters designed to strap on to the pipe. Meter flow range shall be -40-40 feet/second for liquid service. Accuracy shall be +/-0.5% of rate. Repeatability shall be .10% of rate. A D.C. powered transmitter shall be mounted on a wall within 25 feet of the flow meter and be tagged for it's use. Flow transmitter output shall be 4-20 mA linear with flow. There shall be an option for two RTD temperature sensors for BTU calculation. Option will be taken when directed by points list. The water flow meter shall be Emco "Sono Trak" or equal. Insulator will provide removable insulation where transducers are mounted to pipe for service.

I. VORTEX SHEDDING FLOW METERS

1. Provide vortex shedding flow meter for steam metering locations. Meter shall be pressure and temperature compensated, rated for service conditions and be manufactured by Sparling or approved equal. Provide remote readout of pressure, flow, MLb/Hr and total MLb.

2. Coordinate location to provide proper straight run of pipe, pipe size, etc.

3. Power 24VDC power supply as required from Emergency source.

4. BMS system shall monitor Mlb/Hr, Mlb total, pressure and temperature values.

J. RELAYS.

1. Control relays shall be UL listed plug-in type with dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.

2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable ±200% (minimum) from set point shown on plans. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure when not installed in local control panel.

K. OVERRIDE TIMERS.

1. Override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration as required by application. Provide 0-to-6-hour calibrated dial unless otherwise specified. Timer shall be suitable for flush mounting on control panel face and located on local control panels or where shown.

L. CURRENT TRANSMITTERS.

1. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and ±1% full-scale accuracy at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

M. CURRENT TRANSFORMERS.

1. AC current transformers shall be UL/CSA Recognized and completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Transformers shall be fixed-core or split-core type for installation on new or existing wiring, respectively.

N. VOLTAGE TRANSMITTERS.

1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4 to 20 mA output with zero and span adjustment.
2. 2 Ranges shall include 100 to 130 VAC, 200 to 250 VAC, 250 to 330 VAC, and 400 to 600 VAC full-scale, adjustable, with ±1% full-scale accuracy with 500 ohm maximum burden.
3. Transmitters shall be UL/CSA Recognized at 600 VAC rating and meet or exceed ANSI/ISA S50.1 requirements.

O. VOLTAGE TRANSFORMERS

1. AC voltage transformers shall be UL/CSA Recognized, 600 VAC rated, complete with built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C to 55°C (40°F to 130°F) and shall provide ±0.5% accuracy at 24 VAC and a 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic material.

P. POWER MONITORS

1. Power monitors shall be the three-phase type furnished with three-phase disconnect/shorting switch assembly, UL Listed voltage transformers, and UL Listed split-core current transformers.
2. They shall provide a selectable rate pulse output for kWh reading and a 4 to 20 mA output for kW reading. They shall operate with 5 A current inputs with a maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

Q. CURRENT SWITCHES.

1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

R. PRESSURE-ELECTRIC (PE) SWITCHES

1. Shall be metal or neoprene diaphragm actuated, operating pressure rated 0-175 kPa (0-25 psig), with calibrated scale set point range of 14-125 kPa (2-18 psig) minimum, UL listed.

2. Provide one or two-stage switch action SPDT, DPST, or DPDT, as required by application. Electrically rated for pilot duty service (125 VA minimum) and/or for motor control.
3. Shall be open type (panel-mounted) or enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
4. Shall have a permanent indicating gauge on each pneumatic signal line to PE switches.

S. ELECTRO-PNEUMATIC (E/P) TRANSDUCERS.

1. Electronic/pneumatic transducer shall provide a proportional 20 to 100 kPa (3 to 15 psig) output signal from either a 4 to 20 mA or 0 to 10 VDC analog control input.
2. E/P transducer shall be equipped with the following features:
   a. Separate span and zero adjustments
   b. Manual output adjustments
3. Pressure gauge assembly d. Feedback loop control
4. Air consumption of 0.05 L/s (0.1 scfm) at mid-range

T. LOCAL CONTROL PANELS.

1. All indoor control cabinets shall be fully enclosed NEMA 1 construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels.
2. Interconnections between internal and face mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service, individually identified per control/ interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.

2.10 Communication and Control Wiring

A. General:

1. Provide copper wiring, plenum cable, and raceways as specified in the applicable sections of Division 16 unless otherwise noted herein.
2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.

B. Wire Sizing and Insulation

1. Wiring shall comply with minimum wire size and insulation based on services listed below:

	Service	Minimum Gage/Type	Insulation Class
a.			
b.	AC 24V Power	12 Ga Solid	600 Volt
c.	DC 24V Power	10 Ga Solid	600 Volt
d.	Class 1	14 Ga Stranded	600 Volt
e.	Class 2	18 Ga Stranded	300 Volt
f.	Class 3	18 Ga Stranded	300 Volt

2. Provide plenum-rated cable when open cable is permitted in supply or return air plenum where allowed per execution specifications defined in Section 3.

C. Control Wiring:

1. Digital Input/Output wiring shall use Class 2 twisted pair, insulated.

2. Analog inputs shall use Class 2 twisted shielded pair, insulated and jacketed and require a grounded shield.

3. Actuators with tri-state control shall use 3 conductor with same characteristics

D. Communication Wiring

1. Ethernet Cable shall be minimum CAT5
2. Secondary level network shall be 24 gage, TSP, low capacitance cable

E. Approved Cable Manufacturers:

F. Wiring from the following manufacturers which meet the above criteria shall be acceptable:
1. Anixter
2. Belden

PART 3 – EXECUTION

3.1 Examination:

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started.

3.2 Protection:

A. The contractor shall protect all work and material from damage by its employees and/or subcontractors and shall be liable for all damage thus caused.

B. The contractor shall be responsible for its work and equipment until finally inspected, tested, and accepted.

3.3 Coordination:

A. Site

1. The project coordination between trades is the responsibility of the prime contractor who is the one tier higher contractual partner such as mechanical contractor, general contractor, construction manager, owner or owner's representative as applicable.

2. The controls contractor shall follow prime contractor's job schedule and coordinate all project related activities through the prime contactor except otherwise agreed or in minor job site issues. Reasonable judgment shall be applied.

3. Where the work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment.

4. If the contractor deviates form the job schedule and installs work without coordinating with other trades, so as to cause interference with work of other

trades, the contractor shall make the necessary changes to correct the condition without extra charge.

5. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Submittals

1. Refer to the “Submittals” article in Part 1 of this specification for requirements.

C. Test and Balance

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

D. Life Safety

1. Duct smoke detectors required for air handler shutdown are supplied under Division 16 of this specification. That contractor shall interlock smoke detectors to air handlers for shutdown as described in Part 3, “Sequences of Operation.” That contractor will also provide auxiliary contacts for when mecessary to monitor fire alarm status.

2. Smoke dampers and actuators required for duct smoke isolation are provided under another Section of Division 15. The Div 16 contractor shall interlock these dampers to the air handlers where described in Part 3, “Sequences of Operation.”

3. Fire/smoke dampers and actuators required for fire rated walls are provided under another Section of Division 15. Control and interlock of these dampers shall be by Division 16.

E. Coordination with controls specified in other sections or divisions.

1. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor as follows:
   a. All communication media and equipment shall be provided as specified in Part 2, “Communication” of this specification.
   b. Each supplier of controls product is responsible for the configuration, programming, startup, and testing of that product to meet the sequences of operation described in this section. This contractor will monitor and adjust their parameters only through the system specified here.
   c. The Contractor shall coordinate and identify any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
   d. Each supplier of controls product is responsible for providing software database for properly configuring the communications to that system 8 weeks prior to scheduled start-up. Contractor will notify all appropriate parallel contractors of this need.
   e. The contractor is responsible for the interface of control products provided by multiple suppliers when the supplier has a BacNet or another acceptable open protocol device. Systems to be integrated will be shown on the drawings, points list, control details or sequence of operation.

3.4 General Workmanship:

A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).

D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.

E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.

3.5 Field Quality Control:

A. Contractor shall have a quality manager on staff to inspect the project execution and to enforce quality standards.

B. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.

C. Contractor shall continually monitor the field installation for code compliance and quality of workmanship.

D. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.6 Wiring:

A. All control and interlock wiring shall comply with national and local electrical codes and Division 16 of this specification. Where the requirements of this section differ from those in Division 16, the requirements of this section shall take precedence.

B. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved conduit according to NEC and Division 16 requirements.

C. All low-voltage wiring shall meet NEC Class 2 requirements. (Low-voltage power circuits shall be sub fused when required to meet Class 2 current limit.)

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in conduit may be used provided that cables are UL Listed for the intended application. For example, cables used in ceiling plenums shall be UL Listed specifically for that purpose.

E. All wiring in mechanical, electrical, or service rooms—or where subject to mechanical damage— shall be installed in EMT conduit.

F. Do not install Class 2 wiring in conduit containing Class 1 wiring. Boxes and panels containing high 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).

G. Where plenum rated cable is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 3 m (10 ft) intervals.

H. Where plenum rated cable is used without conduit, it shall be supported from or anchored to structural members. Cables can be supported by or anchored to ductwork or ceiling suspension systems. Cables can not be supported by conduit or sprinkler piping.

I. All wire-to-device connections shall be made at a terminal block or wire nut. All wire-to-wire connections shall be at a terminal strip or wire nut.

J. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

K. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers or interposing relays.

L. All plenum rated wiring shall be installed as continuous lengths, with no splices permitted between termination points.

M. All wiring in conduit shall be installed as continuous lengths, with no splices permitted between termination points or junction boxes.

N. Maintain fire rating at all penetrations. Install plenum wiring in sleeves where it passes through walls and floors.

O. Size and type of conduit and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.

P. Include one pull string in each conduit 3/4 in. or larger.

Q. Control and status relays are to be located in designated enclosures only. These enclosures can include packaged equipment control panel enclosures unless they also contain Class 1 starters.

R. Conceal all conduit, except within mechanical, electrical, or service rooms. Install conduit to maintain a minimum clearance of 15 cm (6 in.) from high-temperature equipment (e.g., steam pipes or flues).

S. Secure conduit with conduit clamps fastened to the structure and spaced according to code requirements. Conduit and pull boxes may not be hung on flexible duct strap or tie rods. Conduits may not be run on or attached to ductwork.

T. Adhere to this specification's Division 16 requirements where conduit crosses building expansion joints.

U. The Contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

V. Flexible metal conduits and liquid-tight, flexible metal conduits shall not exceed 1 m (3 ft) in length and shall be supported at each end.. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.

W. Conduit must be 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.

3.7 Communication Wiring:

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification.

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 raceway and junction boxes containing Class 1 or other Class 2 wiring from another trade such as fire alarm or security.

D. Maximum pulling, tension, and bend radius for 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 the cable installation. Use appropriate test measures for each particular cable.

F. All runs of communication wiring shall be unspliced length when that length is commercially available.

G. All communication wiring shall be labeled to indicate origination and destination data.

H. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.8 Fiber Optic Cable System:

A. Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

C. All terminations need to be made into a patch panel, designed for such use. Free air terminations with patch panels are prohibited.

3.9 Installation Of Sensors:

A. General:

1. Install sensors in accordance with the manufacturer's recommendations.

2. Mount sensors rigidly and adequately for the environment within which the sensor operates.

3. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

4. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

5. Sensors used in mixing plenums shall be of the averaging type.

6. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the full face of the coil.

7. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

8. Install outdoor air temperature sensors on north wall, complete with sun shield at designated location.

B. Room Instrument Mounting

1. Room instruments, including but not limited to wall mounted thermostats and sensors located in occupied spaces shall be mounted 53 inches above the finished floor unless otherwise shown. Drawing notes take precedence to this height requirement.

C. Instrumentation Installed in Piping Systems

1. Thermometers and temperature sensing elements installed in liquid systems shall be installed in thermowells.

2. Gauges in piping systems subject to pulsation shall have snubbers.

3. Gauges for steam service shall have pigtail fittings with isolation valve.

D. Temperature Limit Switch

1. A temperature limit switch (Low Temperature Detector) shall be provided to sense the temperature.

2. A sufficient number of temperature limit switches shall be installed to provide complete coverage of the duct section.

3. Manual reset limit switches shall be installed in approved, accessible locations where they can be reset easily.

4. The temperature limit switch sensing element shall be installed in a serpentine pattern and in accordance with the manufacturer's installation instructions.

5. Each bend shall be supported with a capillary clip. Provide 3 m of sensing element for each 1 m^2 (1 ft of sensing element for each 1 ft^2) of coil area.

E. Averaging Temperature Sensing Elements

1. Sensing elements shall be installed in a serpentine pattern.

2. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.

F. Water Differential pressure sensors

1. Differential pressure sensors shall be installed with valved taps into the piping to ensure serviceability without draining the system.

2. Sensors shall be mounted with bleed valves.

3. After sensor installation any air shall be eliminated using the bleed valves to ensure reading accuracy.

4. The sensors shall be located to ensure accessibility.

G. Flow Switch

1. Use manufacturers designated paddle for pipe diameter.

2. Adjust flow switch in accordance with manufacturer’s instructions.

3. This contractor only responsible for identifying the location of the switch. Piping contractor installs the switch on the pipe.

3.10 Wireless Transceiver Installation

A. Mount transceivers in a grid like pattern not exceeding more than 25 - 100 feet line of sight between devices. Location of each transceiver shall be optimally chosen to get the best line of sight between it and at least two of its neighbors.

B. Transceivers may be mounted in the plenum space. Transceivers mounted in a metal enclosure shall utilize a remote mount antenna attached outside the metal enclosure to maintain adequate signal strength.

C. All transceiver antennas must be oriented in the vertical plane for proper RF communication.

D. Once installed ensure good communication is taking place between each device and at least two of its neighbors. Install extra transceivers if necessary to act as routers\repeaters for isolated devices with poor communication to the network.

E. Contractor shall provide a report to the owner or owner's representative illustrating good communication between all devices on the wireless network.

3.11 Actuators:

A. Mount and link control damper actuators according to manufacturer's instructions.

1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.

2. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.

3. Damper manufacturer shall provide all mounting hardware and linkages for actuator installation.

B. Electric/Electronic

1. Dampers: Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5° available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.

2. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.12 WARNING LABELS AND IDENTIFICATION TAGS

A. Equipment and Device labeling:

1. Labels and tags shall be keyed to the unique identifiers shown on the As-Built drawings.

2. All Enclosures and DDC Hardware shall be labeled.

3. Airflow measurement arrays shall be tagged to show flow rate range for signal output range, duct size, and pitot tube AFMS flow coefficient.

4. Tags shall be plastic or metal and shall be mechanically attached directly to each device or attached by a metal chain or wire.

5. Labels exterior to protective enclosures shall be engraved plastic and mechanically attached to the enclosure or DDC Hardware.

6. Labels inside protective enclosures may be attached using adhesive, but shall not be hand written.

7. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.

8. Identify room sensors relating to terminal box or valves in permanent ink inside the door of the sensor.

9. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

B. Identification of Tubing and Wiring

1. All wiring and cabling including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

2. Permanently label or code each point of field terminal strips to show the instrument or item served.

3.13 Identification Of Hardware And Wiring:

A. All wiring and cabling, including that within factory-fabricated panels shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.

B. Permanently label or code each point of field terminal strips to show the instrument or item served.

C. Identify control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

D. Identify room sensors relating to terminal box or valves with permanent ink inside the door of the sensor.

E. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.

F. Identifiers shall match record documents.

3.14 PROGRAMMING:

A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free within the primary controller for future use.

B. Point Naming: System point names shall be modular in design, allowing easy operator interface without the use of a written point index. Point Naming standard shall be agreed upon between owner and BAS contractor prior to any programming being written. Refer to Submittals section in the General Section.

C. Software Programming

1. Provide programming for the system and adhere to the sequences of operation provided. The contractor also shall provide all other system programming necessary for the operation of the system, but not specified in this document. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation and be of different font and color in text editor. Use the appropriate technique based on one of the following programming types:
   a. Text-based:
      1) Must provide actions for all possible situations
      2) Must be modular and structured
      3) Must be commented
      4) Must provide line by line programing and compilation wizard to allow for ease of editing.

D. Operator Interface

1. Standard graphics—Provide graphics for all mechanical systems and floor plans of the building (architect is responsible for providing floor plans of job to the contractor). This includes each chilled water system, hot water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points such as set points.

2. Show terminal equipment information on a “graphic” summary table. Provide dynamic information for each point shown.

3. The contractor shall provide all the labor necessary to install, initialize, start up, and troubleshoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third-party software installation and integration required for successful operation of the operator interface.

4. Contractor shall provide necessary programming to create all reports referred to in Part 2 Operator Interface Software.

3.15 CONTROL SYSTEM CHECKOUT AND TESTING

A. Perform a two-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

B. Phase I – Field I/O Calibration and Commissioning

1. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Contractor will fill out daily reports with the general contractor when this work is being done so that the general contractor can notify the owner if they want to review this work. Contractor will provide a detailed commissioning report showing that this work was done. Commissioning to include, but not be limited to:

a. Sensor accuracy at 10, 50 and 90% of range.
b. Sensor range.
c. Verify analog limit and binary alarm reporting.
d. Point value reporting.
e. Binary alarm and switch settings.
f. Actuator and positioner spring ranges if pneumatic actuation is utilized.
g. Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

C. Phase II – System Commissioning

1. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner, his engineer or their designated representative, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

2. The demonstration process shall follow that approved in Phase 1, The approved checklists and forms shall be completed for all systems as part of the demonstration.

3. The contractor shall provide at least one person equipped with two-way communication and shall demonstrate actual field operation of each control process for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The purpose is to demonstrate the response, and action of every point and system while under control. Any test equipment required to prove the proper operation shall be provided by and operated by the contractor.

4. Demonstrate compliance with sequences of operation through all modes of operation.

5. Demonstrate complete operation of operator interface.

6. Additionally, the following items shall be demonstrated:
   a. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall require further tuning by the Contractor.
   b. Demand limiting (if specified in sequence). The contractor shall supply a trend data output showing the action of the demand-limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
   c. Optimum start/stop(if specified in sequence). The contractor shall supply a trend data output showing the capability of the algorithm. The change-of value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
   d. Interface to the building fire alarm system(if specified in sequence).

e. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and electronic formats.

7. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

D. Acceptance

1. All tests described in this specification shall have been performed to the satisfaction of both the engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion requirements if stated as such in writing by the engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved for both phase I and phase II.

3.16 CLEANING

A. The contractor shall clean up all debris resulting from their activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.17 TRAINING

A. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed. Factory employed/certified instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays. All sessions will be scheduled one week in advance. If no one shows up after one hour from the start time, that session will be forfeited.

B. Provide a minimum of four (4) on-site, on-line, or classroom training sessions throughout the contract period for personnel designated by the owner. Each session shall be a minimum of eight (8) hours each.

C. Provide two additional training sessions at 6 and 12 months following building's turnover. Each session shall be four hours long and must be coordinated with the building owner.

D. The instructor(s) shall be factory-trained instructors experienced in presenting this material.

3.18 SEQUENCES OF OPERATION

A. Sequence of operations will be the same as shown on all jobs. No deviations will be made on this document for the sequences shown.

3.19 POINTS LISTS

A. Points lists will be the same as shown on all jobs. No deviations will be made on this document for the points lists shown.

END OF SECTION

SECTION 23 60 00

HEATING, VENTILATION, AND AIR CONDITIONING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Section 23 05 00, “Common Work Results for Heating, Ventilation, and Air Conditioning” applies to the work of this Section.

B. The work listed or required by this section of the specifications is not intended to limit or establish the extent of the Heating, Ventilating and Air Conditioning work. The General Contractor shall be responsible for determining the extent of work to be done under a subcontract.

1.2 DESCRIPTION

A. Work Included: The work includes the furnishing of labor, materials, appliances and tools necessary for the installation, in complete working order, of the Heating, Ventilating and Air Conditioning System as herein specified and as indicated on the drawings. The items of work shall include, but shall not be limited to, the following principal items:

1. Equipment including, heating hot water boilers, pumps, etc., as indicated on the drawings.
2. Heating Hot water piping systems, including valves and fittings.
3. Insulation for piping.
4. Condensate drain piping to the drain receptors.
5. Exhaust and ventilation systems including ductwork, etc.
6. Miscellaneous hangers, supports, sleeves, inserts, isolators, flexible connections, seismic bracings, and other auxiliary equipment for all systems under this section.
7. Equipment identification, operations and maintenance instructions.

B. Apparatus, piping, ductwork, etc. shall be installed and interconnected so as to form complete systems.

C. Testing, adjustment and balancing of hydronic systems.

D. Measurement of final operating condition of HVAC Systems.

E. Provide one 4-hour day of instructional time to Owner’s maintenance of personnel by Contractor’s start-up mechanic.

F. Other work herein specified and shown on the accompanying drawings, including addendum, change orders and approved shop drawings.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Work designated on drawings to be installed or performed by other sections of the specifications.

B. Motor starters shall be furnished and installed under Division 26 of the specifications, unless otherwise specified or shown. See equipment paragraphs, this section for packaged equipment to be furnished with starters.

C. Finish painting of equipment, piping and ductwork shall be under Painting Section, except as noted otherwise.

D. Equipment foundations, curbs or equipment pads as provided under the Concrete Section or Structural Steel Section. Coordinate exact foundation sizes and elevations and anchor bolt sizes and locations.

1.4 EQUIPMENT RESTRICTIONS

A. Names of selected manufacturers have been specified for items of equipment and materials. Bids shall be based on the use of the product of one of the selected manufacturers, and only such products may be submitted for approval.

1.5 SUBMITTALS

A. In addition to the requirements of Section 23 05 00, the submittal brochures shall include the following items:
   1. Equipment:
      a. Heating Hot Water Boilers
      b. Primary Heating Hot Water Pumps
      c. Combustion Air Fan
   2. Air Distribution System:
      a. Flue Vent Duct
      b. Combustion Air Duct
   3. Piping System:
      a. Heating Hot Water Pipe Material and Fittings
      b. Condensate Drain Pipe Material and Fittings
      c. Valves
      d. Pipe Hangers and Supports
   4. Insulation:
      a. Ductwork
      b. Piping
   5. Accessories:
      a. Pressure Gauges
      b. Thermometers
   6. Temperature Control Devices and Equipment
      a. Heating hot water boilers

B. Shop Drawings:
   1. Dimension Drawings for concrete pad, curb and equipment foundation at 1/4-inch scale or larger including bolt sizes and locations.
   2. Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations at 1/4-inch scale or larger.
   3. Provide details of suspension and support for ceiling hung equipment.
   4. Where walls, floors, slabs or supplementary steel work are used for seismic restraint 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 attachment and support points.

5. Provide seismic details of seismic restraints and anchors; include number, size and locations for each piece of equipment.
6. Control Wiring Diagrams.
7. Ductwork equipment and piping systems show sections indicating routing and clearances between other trades.
8. Hot water piping plans and sections at 1/4-inch scale or larger.
9. Submit fabrication details for equipment basis including dimensions, structural member sizes and support point locations. Provide details of suspension and support for ceiling hung equipment. Where walls, floors, slabs or supplementary steel work is used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturer's submittals must include spacing, static loads and seismic loads at attachment and support points. Provide specific details for seismic restraints and anchors; include number, size and locations for each piece of equipment.

1.6 VIBRATION ISOLATION

A. Vibration Isolators: Isolators shall have integral seismic restraints and be selected for minimum static deflection of 1-inch or as otherwise noted and in accordance with the equipment manufacturer's weight distribution so as to produce reasonable uniform deflection.

B. Mechanical equipment, piping and ductwork shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonable uniform deflections.

C. Isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.

D. It is the intent of the seismic portion of this specification to keep mechanical building system components in place during a seismic event. Such systems must be installed in strict accordance with seismic codes, component manufacturers and building construction standards. Whenever a conflict occurs between the manufacturers or construction standards, the most stringent shall apply.

E. This specification is to be a minimum requirement for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state construction requirements or other requirements.

F. A variance or noncompliance with these specification requirements shall be corrected by the Contractor in an approved manner.

G. Housekeeping pads shall be coordinated with a restraint vendor and sized to provide a minimum edge distance of ten bolt diameters (or coordinate with Structural engineer for minimum requirement) all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

H. Constructor shall supply supplementary support steel for all equipment, piping, ductwork, etc., including the roof-mounted equipment as required.

I. Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double-sided beam clamps, etc., in accordance with the requirements of the vibration vendor's calculations.

J. Failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8-inch and/or horizontal permanent deformation greater than 1/4-inch.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industries products are the basis of these specifications; products of other manufacturers are acceptable provided their systems comply with the specification and have the approval of the Architect.

B. Two layers of 3/4-inch thick neoprene pad consisting of 2-inch square waffle modules separated horizontally by a 16-gage galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super “W” as manufactured by Mason, Industries, Inc.

C. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2-inch and all-directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing mode neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall be Type BR as manufactured by Mason Industries, Inc.

D. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between two steal sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to horizontally cushion the back panel. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. Neoprene shall be bridge bearing quality. Bushing assemblies shall be type PB as manufactured by Mason Industries, Inc.

E. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be type HG as manufactured by Mason Industries, Inc.

F. Hangers shall consist of rigid steel frames containing minimum 1-1/4-inch thick neoprene elements at the top and a steel spring type SLF with general characteristics as specified above seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushing projecting through the steel box. To maintain stability, the boxes shall not be articulated as clevis hangers and do not stack the neoprene element on top of the spring. Spring diameters and hanger boxes lower hole, and sizes shall be large enough to permit the hanger rod to swing through a 30º capability. Hangers shall be type 30N as manufactured by Mason Industries, Inc.

G. Hangers shall be type 30N, but they shall be recompressed and locked at the rated deflection by means of a resilient seismic up-stop to keep the piping or equipment at a fixed elevation during installation. The handlers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30 degree capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

H. Steel angles, sized to prevent buckling, shall be clamped to pipe or rod, utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods

is not acceptable. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

I. Pipe clevis crosses bolt braces and are required in restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall be type CCB as manufactured by Mason Industries, Inc.

J. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3-inch and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged		Male Nipple	
3X14	10X26	12X9	1-1/2X13
4X15	12X28	3/4X10	2X14
5X19	14X30	1X11	2-1/2X18
6X20	16X32	1-1/4X12	
8X22			

1. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts whenever possible. Hoses shall be type BSS as manufactured by Mason Industries, Inc.

K. All-directional acoustical pipe anchors, consisting of two sizes of steel tubing separated by a minimum 1/2-inch 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-psig and the design shall be balanced for equal resistance in each direction. All-directional anchors shall be typed ADA as manufactured by Mason Industries, Inc.

L. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2-inch 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-inch motion or to meet G6. Pipe guides shall be type VSG as manufactured by Mason Industries, Inc.

M. Split Wall Seals consist of two bolted pipe halves with minimum 3/4-inch thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe to the construction of the building member. Seals shall project a minimum of 1-inch past either face of the surface. Where temperatures exceed 240ºF, a number 10 density, fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

N. The horizontal thrust restraint shall consist of a spring element in series with a neoprene-molded cup type SLF with the same deflection as specified for the mountings for hangers. 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-inch movement at start and stop. The assembly shall be furnished with one 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. Horizontal thrust restraints shall be type WBI/WBD as manufactured by Mason Industries, Inc.

2.2 FLUE VENT DUCTWORK

A. Standards:

1. Where applicable, products furnished under this section shall conform to the requirements of NFPA 54 and NFPA 211, and shall comply with UL 1738, ULC S636 Standard for Venting Systems for Category II, III, and IV Gas-Burning Appliances, and all other applicable standards. Also approved for use with Type L Venting systems (gas or oil) in accordance with UL 641
2. All flue-gas carrying components of the vent system shall be obtained through one source.
3. Vent shall be warranted by the manufacturer against defects in material and workmanship for a period of (15) years from the date of manufacture

B. Product:

1. Vent shall be factory-built special gas type, double wall, engineered and designed for use on Category I, II, III, and IV appliances, or as specified by the equipment manufacturer.
2. Maximum continuous flue gas temperature not to exceed 550°F (288°C) for gas burning appliances. Maximum temperature for appliances approved to vent with Type L-Vent (gas or oil) is 570°F.
3. Vent shall be constructed with an inner conduit constructed of AL29-4C® or 29-4 (S44735) superferritic stainless steel with a minimum thickness of .015" for diameters 3"-8", .020" for diameters 10"-16", .025" for diameters 18"-24", and .035" for 26" and greater.
4. Vent shall be listed for an internal static pressure of 15" w.g. and tested to 37" w.g.
5. All inner wall conduit components shall be manufactured from AL29-4C® or 29-4 (S44735). The joint closure system shall be an Inner Wall Mechanical Locking Strap design. Joints shall not use screws or fasteners that penetrate the inner conduit.
6. Vent shall be constructed with a factory installed gasket used to seal the joint for diameters 4"–16". Use of gasket lube, available from the factory, should be used for maximizing gasket life and ease of installation. For diameters 18"- 32", joints shall be sealed with factory supplied RTV sealant.
7. Inner wall joints shall be designed with a male and female overlapping metal-metal connection to maintain condensate on the AL29-4C stainless steel. Proper ¼" per foot pitch must be maintained at all times and condensate should flow back toward the appliance to the required number of drains.
8. The outer wall casing shall be constructed of 430 stainless steel that shall not require additional surface preparation, such as painting, in order to withstand the outdoors or high humidity environments.
9. Inner conduit and outer wall casing shall be constructed with a one-inch air space between them and in such a fashion that prevents cross-alloy contamination. Optional 1" fiber insulation is available to maintain higher flue temperatures, but does not reduce clearances beyond the standard clearances tested for 1" airspace model CI Plus.
10. Tees and elbows shall provide a pressure drop less than 15 feet equivalent horizontal vent.
11. Fittings that increase or decrease vent diameter shall be asymmetric in construction with a flat wall that maintains a straight line with adjoining parts in order to facilitate the unobstructed flow of all condensate.
12. All parts shall be compatible with other single wall and double wall products of the same manufacturer.
13. System is to be sized in accordance with the appliance manufacturer's specifications, NFPA 54-National Fuel Gas Code (ANSI Z223.1), ASHRAE recommendations, and other applicable codes.

C. Sealant:
   1. General Electric RTV106 (aka Momentive) or Dow Corning 736 High Temperature Sealant shall be used to seal all joints on systems where the maximum flue gas temperature will not exceed 550°F.

D. Duct Supports
   1. Duct hangers, spacing of hangers, upper and lower attachments, etc. shall conform to the most stringent requirements of the SMACNA or 2013 California Mechanical Code. See 23 05 00 for seismic requirements.

2.3 PIPING

A. Heating Hot Water
   1. Steel
      a. Pipe: ASTM A-53 Grade A or B, Schedule 40, black steel, seamless.
      b. Fittings:
         1) 2-inch and under: Screwed, malleable iron, black, 150-psig.
         2) 2-1/2-inch and over: Butt-welded, 3-pass, V-weld with beveled pipe ends. Flanges shall be provided where required for servicing and/or removal of equipment and valves. Flanges shall be Class 150, ANSI B16.5, raised face, forged steel, weld neck type.
   2. Copper
      a. Pipe: ASTM B88, type L hard drawn, seamless copper pipe.
      b. Fittings: ANSI/ASME B16.22 wrought copper.
      c. Joints: lead free, tin silver 95-5 alloy solder. Use silver solder joint ANSI 150-psig for flanges.

B. Condensate & Make-up Water
   1. Copper
      a. Pipe: ASTM B88, type L hard drawn, seamless copper pipe.
      b. Fittings: ANSI/ASME B16.22 wrought copper.
      c. Joints: lead free, tin silver 95-5 alloy solder. Use silver solder joint ANSI 150-psig for flanges.

C. Flexible Piping Connector
   1. Manufacturer based upon M.W. Sausse. Equal products by Mason may be submitted for approval.
   2. Wire braded covered annular corrugated hose of stainless steel.

2.4 VALVES

A. General:
   1. Provide valves of first quality of approved manufacture, have proper clearances, and be tight at the specified test pressure. All pressure ratings are in psi steam working pressure, unless otherwise indicated.
   2. Mark on each valve provided with the maker's name or brand, the figure or list number, and the guaranteed working pressure cast on the body and cast or stamped on the bonnet.
   3. Gate and globe valves suitable for repacking under pressure. Regardless of service, valves not acceptable when designed for less than 125 pounds per square inch steam working pressure.
   4. Valves must be of the product of one manufacturer, except for special application.

5. Figure numbers of manufacturers are listed to indicate the types selected for design, performance and standard of quality.
6. Construct valves to meet Federal Specifications and Manufacturers Standardization Society of the Valve and Fitting Industry.
7. Butterfly valves to be installed in non-potable piping systems only, unless specifically approved for potable water systems by authorities having jurisdiction.

B. Manufacturer:
1. Gate, Globe, Stop Check, and Swing Check Valves: Nibco or equivalent by Walworth, Hammond, Stockham or Jenkins.
2. Spring Loaded Check Valves: Nibco or equivalent by Hammond, Miller Silent or Mueller.
3. Butterfly Valves: Nibco or equivalent by Demco, Hammond, Mueller, Keystone or Stockham.
4. Ball Valves: Nibco or equivalent by Walworth, Hammond, Jenkins or Dynaquip.
5. Plug Valves: Keystone/Drum-Owen or equivalent.
6. Gas Cocks: Walworth or equivalent by Homestead or Stockham.

C. Gate Valve - Water Service up to 140°F.
1. 2” and Smaller: Class 150, 150 PSI SWP, bronze threaded rising stem, inside screw, union bonnet, solid wedge bronze disc. Nibco T-134.
2. 2-1/2” and Larger: Class 150, 150 PSI SWP, ductile iron body, flanged, outside screw and yoke, bolted bonnet, bronze trim. Nibco F-637-31.

D. Gate Valve - Steam and Water Service over 140°F:
1. 2” and Smaller: Class 300, 300 PSI SWP, bronze, rising stem, inside screw, union bonnet, threaded end, solid bronze disc, stainless steel seats. Nibco T-174-SS.
2. 2-1/2” and Larger: Class 250, 250 PSI SWP, iron body, flanged, outside screw and yoke, bolted bonnet, bronze mounted. Nibco F-667-0.

E. Globe Valves:
1. 2” and Smaller: Class 300, 300 PSI SWP, bronze, threaded, renewable teflon disc, union bonnet. Nibco T-275.
2. 2-1/2” and Larger: Class 250, 250 PSI SWP, iron body, flanged, renewable seat and disc, bolted bonnet, bronze mounted. Nibco F-768-B.

F. Stop Check Valve: Class 250, 250 PSI SWP, cast iron body, flanged, bolted bonnet, renewable seat and disc, bronze mounted. Nibco F-869-B.

G. Swing Check Valve - Water Service up to 140°F (for Horizontal Installation Only):
1. 2” and Smaller: Class 150, 150 PSI SWP, bronze, threaded, horizontal swing, Y-pattern, renewable teflon disc, regrinding type, screw-in cap. Nibco T-433.
2. 2-1/2” and Larger: Class 125, 125 PSI SWP, iron body, flanged, horizontal swing, renewable bronze disc and seat ring, regrinding type, bolted bonnet, bronze trim. Nibco F-918.

H. Swing check Valve - Steam and Water Service over 140° (for Horizontal Installation Only):
1. 2” and Smaller: Class 300, 300 PSI SWP, bronze, threaded, horizontal swing, Y-patter, renewable teflon disc, regrinding type, screw-in cap. Nibco T-473.
2. 2-1/2” and Larger: Class 250, 250 PSI SWP, iron body, flanged, horizontal swing, renewable bronze disc and seat ring, regrinding type, bolted bonnet, bronze trim. Nibco F-968-B.

I. Spring Loaded Check Valves - (For Vertical Installation Only):
   1. 2” and Smaller: Class 125, 125 PSI SWP, bronze body, threaded, center guided stainless steel disc, teflon seat, stainless steel spring and trim. Nibco T-480.
   2. 2-1/2” and larger: Cast iron, globe type body, flanged, 250 lb. WOG, center guided bronze disc, Buna-N seat, stainless steel spring and trim. Nibco F-960.

J. Butterfly Valves – for service up to 225°F:
   1. Valves: Iron body of the lug type, stainless steel upper and lower stems, stainless steel disc, EPT (EPDM) seat, 250 lb. working pressure form -40°F to 225°F limited fluid temperature. Nibco LD-3022.
   2. Valves designed for installation between Std. ANSI 125/150 flanges. Lug holes threaded.
   3. Valves 3” and Smaller: Provide lever operator with position indicator.
   4. Valves 4” and Larger: Provide gear operator with position indicator.
   5. Valves on insulated piping to be provided with a neck extension 2” above outside diameter of flanges to accommodate full thickness of insulation.

K. Ball Valves 2” and Smaller: Full port, three-piece, threaded bronze body, Type 316 stainless steel stem and ball, reinforced TFE seat ring, extended blowout stem with vapor seal and protective sleeve for insulated piping, lever or tee handle, 150 lb. SWP. Nibco T-595-Y-66.

L. Ball Valves 2-1/2” and Larger: Full port, two-piece, flanged stainless steel body, Type 316 stainless steel stem and ball, reinforced RTFE seat and liner, extended blowout stem for insulated piping, lever handle with position indicator for sizes 3” and smaller and gear operator with position indicator for sizes larger than 3”, 150 lb. SWP. Nibco F515.

M. Plug Valves:
   1. 2” and Smaller: Cast iron body, screwed, EPDM coated eccentric plug, pet cocks, memory stop, non-lubricated, 175 lbs. WOG. Keystone/Drum-Owen 1512.
   2. 2-1/2”and Larger: Flanged, non-lubricated, cast iron body and EPDM coated eccentric plug, pet cocks, memory stop, non-lubricated, 175 lbs. WOG. Keystone/Drum-Owen 1522.

N. Chain Operators: Provide on all valves installed 8’ or higher from floor to platform, except where valves are installed above ceilings outside of mechanical rooms.

2.5 STRAINERS

A. Description: Y-type with strainer baskets of material and perforations suitable for steam or water service, as required. Figure numbers of manufacturers are listed to indicate the types selected for design, performance and standard of quality.

B. Manufacturer: Spirax Sarco or equivalent by Mueller or Hoffman.

C. 2” and Smaller: Full pipeline size, 250 lb. SWP bronze, with screwed ends and a removable plug type screen retainer. Sarco Type BT.

D. 2-1/2” and Larger: Full pipeline size, 250 lb. SWP semi-steel, with flanged ends and a bolted screen retainer. Sarco Type AF-250.

E. Screens: Stainless steel or monel screen with 20 mesh screen opening.

F. Provide a blowdown valve with a drain line to discharge above an approved receptor on the blowdown connection of the strainer. Where strainers occur above ceilings, provide a blowdown valve with 3/4” capped hose adapter fitting.

2.6 PIPING ACCESSORIES

A. Calibrated Flow Valve
   1. Manufacturer based upon Bell & Gossett Circuit Setter.
   2. Size 2-inch and smaller:
      a. Bronze body/brass ball with glass and carbon filled TFE Seat Rings.
      b. Valves shall have differential pressure read-out ports across valve seat area. Read-out ports shall be fitted with internal EPT inserts and check valves.
      c. Valve body shall have 1/4-inch NPT tapped drain/purge port. Valve to have memory stop feature to allow valve to be closed for service and then reopened to set point without disturbing balance position.
      d. Valve shall have calibrated nameplate to assure specific valve setting.
      e. Valve shall be preformed insulation to permit access for balance and read-out.
   3. Size 2-1/2-inch and larger:
      a. Valve shall have flanged connection suitable for 125-psig working pressure at 250ºF, equipped with brass readout valves fitted with an integral EPT insert, and check valve designed to minimize system fluid loss during balancing and monitoring process.
      b. Valve shall have a calibrated nameplate to assure specific valve setting. Valve shall be constructed with internal seals to prevent leakage.

B. Union
   1. Manufacturer based upon Crane. Equal products by Zurn or Armstrong may be submitted for approval.
   2. Provide adjacent to screwed valves.

C. Combination Temp/Press Sensing Station
   1. Manufacturer based upon Peterson Engineering Company model Pete's Plug.
   2. Provide in entering and leaving water to each coil, pump and boiler.
   3. Plug shall have a gasketed cap.

D. Water Pressure Gauge
   1. Manufacturer based upon Weiss model LF4UGY2. Equal products by Trerice or Marsh may be submitted for approval.
   2. Dial type, 4-1/2-inch face, 0 to 1000-psig, fiberglass reinforced polypropylene case with "O" ring weatherproof seals, liquid filled (glycerin), stainless steel movement, phosphor bronze bourdon tube silver brazed to socket and tip, and a replaceable acrylic window with "O" ring seal for weatherproof service. Accuracy: ±1% of full scale.
   3. Provide one gauge at each device. Manifold gauge to each of the following locations with 1/4-inch IPS galvanized steel pipe and individual shut-off needle valves at each location as follows:
      a. Inlet of Y-body strainer ahead of the pump.
      b. Gauge tapping at suction flange of the pump.
      c. Gauge tapping at discharge flange of the pump.
      d. Upstream and downstream of pressure regulators.
      e. Inlet and outlet of each coil.

E. Water Thermometer
   1. Manufacturer based upon Weiss model Vari-Angle. Equal products by Trerice or Marsh may be submitted for approval.
   2. Vertical 9-inch inch digital reading scale, adjustable angle type, for insertion into a thermometer well in piping.
   3. Range: 30ºF to 240ºF.

4. Hot water: Provide as indicated on piping flow diagrams and coil details, but as a minimum at hot water supply and return piping at each coil and boiler.

2.7 SAFETY RELIEF VALVES

A. Type: ASME rated and certified by National Board. Valves 2" and smaller bronze with screwed connections. Valves 2-1/2" and larger flanged, cast iron with bronze trim. Provide discharge elbow at the valve discharge.

B. Manufacturer: Spirax Sarco or equivalent by Kunkle, Keckley or Consolidated.

2.8 AIR ELIMINATION

A. Air Vents
   1. Manufacturer based upon Hoffman Model 500. Equal products by Bell & Gossett or Watts Regulator may be submitted for approval.
   2. Provide manual air vents at all piping systems high points and coil headers for proper elimination of air from the piping system. Air vents shall have 1/8-inch NPT straight shank connection. For air vents located inside the building, extend 1/2-inch copper drain pipe from vent to nearest drain receptor.

2.9 INSULATION

A. Pipe fittings and valves and duct thickness shall conform to International Energy Conservation Code as a minimum. Use thickness specified, if greater than International Energy Conservation Code requirements. Insulation to have a flame spread of not more than 25 and a smoke density not exceeding 50 when tested as a composite.

B. Pipe
   1. Manufacturer based upon Johns Manville. Equal products by Knauf or Owens Corning may be submitted for approval.
   2. Micro-Lok
      a. Rigid molded fiber glass pipe insulation meeting ASTM C 547.
      b. Chilled water thermal conductivity ("k") value of 0.23-Btu*in/(hr*ft^{2}*^{o}F) at 75^{o}F.
      c. Heating hot water thermal conductivity ("k") value of 0.29-Btu*in/(hr*ft^{2}*^{o}F) at 200^{o}F.
      d. Maximum service temperature of 850^{o}F.
      e. Provide vapor retarder jacket AP-T PLUS white kraft paper reinforced with glass fiber yarn and bonded to aluminum foil, secures with self sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples or vapor barrier mastic as needed.

C. Equipment
   1. Manufacturer based upon Johns Manville. Equal products by Knauf or Owens Corning may be submitted for approval.
   2. 812 Series Spin-Glas:
      a. Flexible equipment insulation meeting ASTM C 533, Type III.
      b. Thermal conductivity ("k") value of 0.24-Btu*in/(hr*ft^{2}*^{o}F) at 75^{o}F.
      c. Maximum service temperature of 450^{o}F.
      d. Density shall equal 1.50-lb / ft^{3}
      e. Provide aluminum foil reinforced with fiber glass yarn and laminated with fire-resistive adhesive to kraft paper (FSK Reinforced Foil and Paper). Secure with UL listed pressure sensitive tape and / or outward clinch expanding staples and vapor barrier mastic.

D. Pipe Insulation Schedule:
   1. Fiberglass Insulation:
      a. Heating Hot Water – 2-inch thick

E. Equipment Insulation Schedule:
   1. Flexible Fiberglass Blanket
      a. Valves – same as pipe
      b. Existing Air Separator – 1-1/2 inch thick

F. Condensate Drain Piping: Insulate condensate drain piping located inside the building from air cooling coil to drain receptors same as the cold water piping except use 1-inch thick insulation.

G. Pipe insulation located outside shall be 1-inch thicker than shown in Schedule.

2.10 HEATING HOT WTARE BOILER

A. Quality Assurance:
   1. Listing and Labeling: Provide electrically operated components specified in this Section that are listed and labeled.
      a. The Terms “Listed” and “Labeled”: As defined in NFPA 70, Article 100.
      b. Listing and Labeling Agency Qualifications: A “Nationally Recognized Testing Laboratory” as defined in OSHA Regulation 1910.7.
   2. ASME Compliance: Boilers shall bear ASME “H” stamp and be National Board listed.
   3. CSD-1 Compliance: Control devices and control sequences according to requirements of CSD-1.
   4. FM Compliance: Control devices and control sequences according to requirements of FM.
   5. IRI Compliance: Control devices and control sequences according to requirements of IRI.
   6. Comply with NFPA 70 for electrical components and installation.
   7. Test and inspect boilers according to the ASME Boiler and Pressure Vessel Code, Section IV. Boilers shall be test fired in the factory with a report attached permanently to the exterior cabinet of the boiler for field reference.

B. Warranty:
   1. The boiler manufacturer shall warrant each boiler, including boiler, trim, boiler control system, and all related components, accessories, and appurtenances against defects in workmanship and material for a period of twelve (12) months from date of startup (must be within 6 months of date of shipment). Heat exchanger and fuel burner shall be warranted for a period of five (5) years from date of shipment.

C. Certification:
   1. Manufacturer’s Certification. The boiler manufacturer shall certify the following:
      a. The products and systems furnished are in strict compliance with the specifications.
      b. The boiler, burner and other associated mechanical and electrical equipment have all been properly coordinated and integrated to provide a complete and operable boiler.
      c. Each Boiler shall be ASME compliant and National Board listed.
      d. Each boiler shall be CSA certified for at least 92% efficiency based on operating conditions specified for testing under ANSI Z21.13/CSA 4.9.
      e. Each boiler shall be CSD-1 compliant.
   2. Contractor's Certification. The contractor shall certify the following:
      a. The products and systems installed are in strict compliance with the specifications and all applicable local or state codes.

b. The specified field tests have been satisfactorily performed by a factory authorized startup agent.
c. The equipment furnished contains inter-changeable parts with the specified equipment so that all major equipment parts can be obtained from the specified manufacturer.

D. General:
1. Furnish and install factory “packaged” low pressure hot water boiler(s). Each factory “packaged” boiler shall be complete with all components and accessories necessary for a complete and operable boiler as hereinafter specified. Each unit shall be furnished factory assembled with required wiring and piping as a self-contained unit. Each unit shall be readily transported and ready for installation.

E. Components:
1. Heat Exchanger:
a. Each hot water boiler shall consist of a vertical, finned copper tube heat exchanger complete with trim, valve trains, burner, and boiler control system. The boiler manufacturer shall fully coordinate the boiler as to the interaction of its elements with the burner and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
b. The boiler heat exchanger shall have removable cast iron cylindrical headers and integral finned copper tubes. Heat exchangers that consist of a primary and secondary heat exchanger are not acceptable.
c. Each boiler shall be capable of operating with a minimum outlet water temperature of 158^{o}F.
2. Main Gas Train:
a. Each boiler shall be provided with an integral main gas valve train. The main gas valve train(s) shall be factory assembled, piped, and wired. Each gas valve train shall include at least the following:
1) One (1) manual shutoff valve.
2) Two (2) safety solenoid valves. Valves equipped with dual solenoids that can be independently energized for leak testing and must be integrated into a single body design.
3) Air-Gas ratio control (maximum inlet pressure 14” W.C.).
4) One (1) low gas pressure switch (manual reset).
5) One (1) high gas pressure switch (manual reset) as required by code.
6) Two (2) pressure test ports.
b. If gas pressure exceeds 14” W.C. the Contractor shall supply a suitable intermediate gas pressure regulator to reduce the pressure to acceptable levels.
c. The boiler manufacturer shall furnish each boiler with an integral power type fuel burner. The fuel burner shall be an assembly of a gas burner, combustion air blower, valve train, and ignition system. The burner manufacturer shall fully coordinate the burner as to the interaction of its elements with the boiler heat exchanger and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
Each burner shall be located near the top of combustion chamber with combustion gases flowing downward through the heat exchanger and constructed of stainless steel flange with perforated stainless steel inner backing plate and stainless steel outer knit.
d. 5. Each boiler shall be equipped with direct spark ignition. Main flame shall be monitored and controlled by a UV Scanner.
e. Burner shall be capable of a 5:1 turndown.

F. Boiler Safety and Trim Devices:
1. Boiler safety and trim devices shall be as follows:

a. Safety relief valve shall be provided in compliance with the ASME code. Contractor is required to pipe to an acceptable drain.
b. Water pressure/temperature gauge.
c. Low Water/Flow cutoff.
d. Manual reset high limit water temperature controller.
e. Operating temperature control to control the sequential operation of the burner.
f. High and Low Gas Pressure switches as required.
g. UV Scanner Flame Sensor.

G. Boiler Control System:
1. Each boiler shall be provided with all necessary controls, all necessary programming sequences, and all safety interlocks. Each boiler control system shall be properly interlocked with all safeties.
2. Each boiler shall be provided with a “Full Modulating” firing control system whereby the firing rate is infinitely proportional at any firing rate between 20% and 100% as determined by the pulse width modulation input control signal. Both fuel input and air input must be sequenced in unison to the appropriate firing rate without the use of mechanical linkage.
3. Control system shall provide the minimum capabilities:
a. Maintain single set point.
b. Reset the set point based on outdoor air temperature.
c. Boiler shutdown based on outdoor air temperature.
d. Internal dual set point program with an external point of closure.
e. Alarm relay for any manual reset alarm function.
f. Programmable Low Fire Delay to prevent short cycling based on a time and temperature factor for release to modulation.
g. LED Display showing current supply and return temperatures, current set points as well as differential set points. It must also display any fault codes whether automatically reset or manually reset.
h. Local Manual Operation.
i. Cascade control for up to 24 boilers without the need for external control source.
j. Remote Control System (Building Management/Sequencer Control) - The boiler control shall be capable of accepting a 0 to 10vdc remote external analog signal to control the firing rate and temperature setpoint.
k. On board Domestic Hot Water Priority capable of changing from the heating pump to the DHW pump as well as changing the boiler set point from a heating temperature to a higher set point temperature to satisfy the DHW system and then return to the heating mode.
l. Domestic Hot Water may run concurrent with Comfort Heat mode.
m. All equipment shall be provided with necessary communication capabilities and hardware to allow integration with BacNet Communications with building Automation System.

H. Field Quality Control:
1. Manufacturer’s Field Service: Engage a factory authorized service representative to supervise the field assembly of components and installation of boilers, including piping and electrical connections. Report results in writing:
a. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Manufacturer’s representative shall supply a factory authorized service technician to start up the boilers.

I. Training:
   1. The factory authorized service representative shall train Owner's maintenance personnel as specified below:
      a. Operate boiler, including accessories and controls, to demonstrate compliance with requirements.
      b. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
      c. Review data in the maintenance manuals. Refer to Division 1 Section "Contract Closeout".
      d. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data".
      e. Schedule training with Owner with at least 7 days advance notice.

J. Manufacturer: Design based on Harsco Industrial /Patterson-Kelley. Equal products by "RBI" or "Raypack" .

2.11 HEATING HOT WATER PRIMARY (INLINE) PUMPS

A. General: The pump shall be in-line, centrifugal type, bronze fitted. The unit shall be arranged for vertically mounted motor. Capacities and horsepower shall be as indicated in the Equipment Schedule on the drawings. Each pump shall be factory tested.

B. Casing shall be cast iron, designed for maximum working pressure of 175 PSIG with 125 lb., ANSI flange drilling and suction and discharge of equal size. Casing shall be furnished with tapings for gauge and drain fittings.

C. The impeller shall be bronze, dynamically and hydraulically balanced for vibration less operation. The impeller shall be keyed to the shaft and secured with a locknut and impeller washer.

D. Motor shall be standard NEMA JM and JP vertical solid shaft.

E. Manufacturer: Design based on " Weinman". Equal products by "Bell and Gossett" or "Grunfos".

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. General: Install work as indicated, in accordance with manufacturer's instructions. Locate properly, plumb and level and securely attach to substrate foundations.

3.2 VIBRATION ISOLATORS

A. Vibration isolators must be installed in strict accordance with the manufacturers written instructions and certified submittal data.

B. Installation of vibration isolators must not cause any change of position of equipment, piping or ductwork resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless insulation unless otherwise specified. “Building” includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. 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 architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor’s expense.

G. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible Contractor’s expense.

H. Correct, at no additional cost, installations that are deemed defective in workmanship and materials at the Contractor’s expense.

I. Over stressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from flanges of structural beams.

J. Drill in concrete anchors for ceiling and wall installation shall be stud wedge type or female wedge type for floor mounted equipment as specified under products.

K. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

L. Where piping passes through walls, floors or ceilings, the vibration isolation manufacturer shall provide split wall seals as specified under products.

M. Air handling equipment and centrifugal fans shall be protected against excessive displacement, which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be as specified under products.

N. Locate isolation hangers as near to the overload support structure as possible.

O. Horizontal pipe isolation: The first three pipe hangers in the main lines near the mechanical equipment shall be vibration isolated. These hangers must also be used in all transverse braced isolation location. Floor supported piping shall rest on vibration isolators. Heat exchanger’s and expansion tanks are considered part of the piping run. The first three isolators from the isolated equipment will have the same static detection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces, the first three hangers shall have minimum 0.75-inch deflection for pipe sizes up to and including 3-inch, minimum 1-1/2-inch deflection for pipe sizes up to and including 6-inch minimum and 2-inch deflection thereafter. Hangers shall be anchored to the overhead structure. Where piping connects to mechanical equipment, install flexible expansion joints or flexible stainless hoses if flexible expansion joints are not suitable for the service.

P. Riser isolation: Vertical riser support and restraint system shall consist of spring isolators, pipe guides, and vertical restraints. Install vertical riser guides so that clearances are maintained around concentric pipes in the guides. Steel springs shall be a minimum of 0.75-inch 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.

3.3 DUCT SYSTEMS

A. Ductwork installation shall be coordinated with project drawings, notes and specifications.

B. Ductwork shall be fabricated to field measurements established by the Contractor on the job. Ducts shall be of sizes and configuration shown on the drawings.

C. Ducts shall be installed true to line and grade. Horizontal ducts shall be installed tight to structure to leave the greatest possible space under them. Where necessary, changes of elevation in the ducts shall be made to secure this result, but not without approval of the Architect.

D. Should it be found that duct dimensions have been omitted from the drawings, Contractor shall notify the Architect, who will supply the dimensions and the Contractor shall then construct the ducts in accordance with these sizes at no extra charge. Should it be found impractical to install duct of the exact sizes given, a duct of a different shape but having the same resistance shall be installed. The sizes of the substitute duct shall be approved by the Architect.

E. Transverse seams in duct system shall be SMACNA 7-17 pocket lock standing seam sealed airtight with U.L. listed duct sealer which meets Class 1 requirements of NFPA 90-A, as manufactured by “United”, “Duro-Dyne” or approved equal.

F. Ductwork layout: Follow as close as possible layout indicated on drawings. Secondary beams shall be furnished and installed under this Section of the specifications whenever necessary to meet these requirements.

G. Swaged joints: Elbows in round ducts may be adjustable type formed by mechanically interlocked swaged joint. Three-piece adjustable elbows may be used for turns up to 45-degrees and five-piece elbows shall be used for turns greater than 45-degrees. Apply duct sealer to swaged joints to seal against air leakage.

H. Tees and elbows connecting to round spiral ductwork shall have crimped ends for insertion limits. Tee fittings are required for all tee connections in conjunction with spiral ductwork. Cutting of the spiral ductwork for direct connection of a tee branch is prohibited.

I. Branch duct outlets of tee fittings may be attached using Pittsburgh lock, clinch lock, and/or inside the collar attached with sheet metal screws and continuously caulked with duct sealer.

J. Connection of round to rectangular ducts: Where more than one round duct connects into a rectangular plenum, spin-in fittings with manual damper or fittings with collars (having manual damper) attached by sheet metal screws may be used. These shall be completely made airtight at the joint by continuous caulking with duct sealer. Provide an adjustable extractor.

K. Attach crimped and slip-in joints with sheet metal screw and make airtight with continuous caulking with duct sealer.

L. Flexible round duct connectors: Length of a flexible round duct connector in any branch duct shall not exceed 6-ft, but shall not be less than directed. The installation shall be such that the centerline radius of a bend shall be not less than two diameters. Connections to metal fittings shall be made with sealer and strap clamps. Excess length of the connector shall be cut off and not bunched together, thus impeding a proper air blow. Flexible connectors shall not penetrate a wall without the Architect’s approval.

M. Duct materials: Sides, including bottom and top of ducts and plenums, shall be constructed of sheet metal. No portion of the building construction, such as walls or slabs, shall be used as part of any duct or plenum unless called for on the drawings or otherwise specified.

N. Ductwork dimensions: Duct dimensions indicated are inside dimensions for the net free area. If ducts are lined, the duct dimensions indicated are dimensions for the net free area inside the lining and the outer, or overall, dimensions of the actual ducts shall be increased accordingly to accommodate the duct lining specified.

O. Ductwork installation: Ductwork shall be installed true to line and grade and with seismic restraints in accordance with the Seismic Bracing Notes on drawing M-0.1 and Section 15010.

P. Ducts shall not be supported from decking. Furnish and install secondary structural members to span steel purlins to distribute the load. Refer to roof shop drawings for location of beams and purlins for additional structural members for hangers.

Q. Outlets Installation: Diffusers, registers, and grilles in ceilings and walls shall be located in accordance with Architectural reflected ceiling plans and interior elevation plans whenever such drawings exist. Locations on Mechanical Drawings are approximate.

R. Changes in Duct Elevation, unless otherwise shown, fitting shall be made by either of the following:
   1. By curved sections of a minimum throat radius equal to the duct dimension in the place of the bend.
   2. By mitered elbows made with double thickness (formed) type turning vanes. Turning vanes in mitered elbows in lined ducts shall be factory manufactured extruded aluminum double thickness (formed) types with acoustical insulation between double wall and shall be approved equal to Sono Turn, manufactured by Sound Control Products Co., Palo Alto, California.

S. Duct Transition Sections: Changes in the size of ducts shall be made by uniformly tapering sections with a maximum included angle having a slope of 4-inch in transition length for each inch of transition. Length of transition shall be determined by the side with the largest amount of transition.

T. Flashing Duct through Roof: Install flashing to cover top and sides of curb and fit closely around duct. Cover top edge of base flashing with a collar soldered to duct and turned down over base flashing. Fabricate flashing from minimum 24-gage galvanized steel sheet.

3.4 ACCESS TO EQUIPMENT

A. General:
   1. Ductwork, equipment, and accessories shall be installed to permit access for maintenance.
   2. Relocation of conduit, piping, equipment, and accessories required to provide maintenance access shall be accomplished by the Contractor at no additional cost to the Owner.

B. Access:
   1. Provide access doors where any dampers, instruments, controls, motors and other equipment requiring access for servicing, repairs or replacement are located behind walls, chases, or above non-removable ceilings.
   2. The location of access doors shall be coordinated with and installed by the applicable trade installing walls or ceilings. The final locations of access doors shall coordinate with Architect.

3. Contractor shall arrange for the necessary openings in the building to allow for admittance of all apparatus.

3.5 PIPING SYSTEMS

A. General: Apparatus, fixtures, devices and appliances which require pipe connections shall be so equipped and each such pipe connection shall be valved or trapped, or provided with special apparatus as indicated on the drawings or elsewhere specified. Where such connections are not indicated on the drawings or specified, they shall be made in the usual manner recommended by the manufacturer of each such equipment.

B. Reduced fittings shall be used in lieu of bushings. Close nipples will not be permitted.

C. Pipe lines shall be installed in the locations and of the sizes shown on the drawings or specified herein and of the materials and workmanship herein specified and shall be free from all stains, tool marks, or other foreign substances.

D. Piping shall be installed parallel to or at right angles to the building walls. Pipelines shall be installed free from traps and air pockets and true to line and grade. Horizontal lines shall be installed as close to the building construction as possible so as to leave the greatest possible head room under them.

E. The only filler that may be used in making up screw joints in pipe lines shall be an approved graphite paste or Teflon tape.

F. Where pipes of two dissimilar metals are joined, “Mallory” dielectric couplings or approved equal shall be installed.

G. Condensate drain piping shall be installed in accordance with local code. Collect from air coils, fuel-burning condensing appliances, overflows from water-supplied equipment and discharge to approved plumbing fixture. Slope shall not be less than 1%. Size shall not be less than specified CMC.

H. Identification of Piping: Paint and identify piping, as specified in Section 15010.

I. Hangers and Supports:
   1. Horizontal pipe lines shall be carried by hangers or supports spaced according to the following schedule:

SCHEDULE 40 STEEL PIPE		COPPER TUBING	
Size	Maximum Spacing	Tube O.D.	Maximum Spacing
1-1/4” or less	8’-0”	5/8” or less	6’-0”
1-1/2” - 2-1/2”	10’-0”	7/8” – 1-1/8”	8’-0”
3” or larger	12’-0”	2-5/8”-5-1/8”	12’-0”

   2. Where two or more lines are run at the same elevation, trapeze hangers constructed of “Unistrut” or “Elcen” channels with rods as specified herein may be used. Provide separate hangers for each branch offset three feet or more in length. Hangers shall be set so as to allow the pipe to adjust itself to changes produced by expansion and contraction.
   3. Pipes shall not be supported from decking. Furnish and install structural members to span steel purlins to distribute the load. Refer to roof shop drawings for location of beams and purlins to provide additional structural members for hangers. Provide additional supports for upper attachments for piping supports with a secondary steel support system consisting of a structural steel channel securely between beams or

purlins. Furnish additional “Unistrut” channel (back-to-back 1-5/8 x 1-5/8 x 0.010-inch roll formed) members. Clamp, brackets, etc., for complete support of piping and sway bracing. Do not penetrate metal decking with fasteners.

4. Hangers, unless otherwise noted on the drawings, for pipelines shall be heavy-duty clevis type: “Grinnel” Fig. 260 or approved equal. Hangers shall be supported on threaded rod hangers of the following minimum sizes:

PIPE SIZE	ROD DIA.
2” and less	3/8”
2-1/2” and 3”	1/2”
4” and 5”	5/8”
6”	3/4”

3.6 EXPANSION JOINTS, ANCHORS, GUIDES

A. Provide expansion loops and offsets for taking up thermal expansion in hot water heating supply and return piping, as indicted on the drawings or where required, to eliminate intolerable piping movements and stresses on equipment connections and piping.

B. Install swing or swivel joints for connections from mains to riser and from risers to heating units.

C. When installing piping with expansion loops, the piping shall be cold sprung to about half of the total expansion between cold and hot conditions. Cold springing of piping is not permitted.

D. Hot water branch connections shall be installed in such a manner that piping shall have zero stress when hot.

E. Make riser offsets in a manner to avoid pockets forming due to expansion.

F. Where indicated on the drawings or where space conditions prevent the use of expansion loops as specified above, furnish and install expansion joints and accessories as specified herein. Where expansion joints are in concealed locations, provide access doors of size to permit inspection, servicing and replacement as required.

G. At each end of expansion loops or joints and adjacent thereto, provide approved pipe guides for pipe alignment. Where piping is insulated at pipe guides, provide protective covering consisting of 16-gage galvanized sheet metal of sufficient length to completely surround the insulation.

H. Provide approved pipe anchors where shown on the drawings or where required to control directional expansion of piping. Thoroughly secure anchors to building construction providing, if necessary, structural steel members of shapes required to accomplish the purpose of the anchors.

3.7 PIPE TESTING

A. Test piping system in accordance with ANSI/ASME B31.9.

B. Test refrigeration system in accordance with ANSI/ASME B31.5.

C. Provide hydrostatic test of 150-psig or 1-1/2 times working pressure, whichever is greater for a period of two hours.

D. Pressure test refrigeration system with dry nitrogen to 200-psig. Perform final tests at 27-inch Hg vacuum and 200-psig using electronic leak detector. Test to no leakage.

E. Fully charge completed system with refrigerant after testing.

3.8 FINAL CONNECTIONS

A. Provide final connections to all equipment including all fill or make-up water for heating and cooling systems.

3.9 WATER TREATMENT FOR CLOSED SYSTEMS (HEATING HOT WATER SYSTEM)

A. General: Supply necessary cleaners, inhibitors and biocides to control corrosion to industry standards.

B. Cleaning:
   1. Flush system with city water; clean individual strainers, expansion tank, dead ends and low flow area of any debris at all stages of cleaning.
   2. Add chemical cleaner per water treatment firm's recommendation.
   3. Circulate for 72-hours. Provide pumps, valves and by-pass piping necessary to provide circulation.
   4. Flush system until appears clean, clean strainers, expansion tank, etc., and continue flushing until the iron content is lower than 1-ppm and phosphate level is equal to that of the city water, but not more than 5-ppm orthophosphate.

C. Add Inhibitor:
   1. In chilled water systems add sufficient inhibitor and biocide to reach a range between 600 to 1,000-ppm nitrate. In heating hot water systems, add a biocide to a range between 800 to 1,500-ppm nitrate.

D. Water treatment supplier shall supervise cleaning and charging and shall submit a report certifying that these operations have been satisfactorily completed.

3.10 EXAMINATION AND PREPARATION

A. Verify that ductwork has been tested for leakage in accordance with SMACNA standards before applying insulation materials.

B. Verify that equipment and surfaces are clean, dry and free of foreign material.

C. Verify piping has been tested as specified.

3.11 INSULATION

A. Install materials in accordance with manufacturer's recommendations, building codes and industry standards.

B. Continue insulation vapor barrier through penetrations, except where prohibited by code.

C. Piping Insulation
   1. Locate insulation and cover seams in least visible locations.
   2. Neatly finish insulation at supports, protrusions and interruptions.

3. Provide insulated dual temperature pipes or cold pipes conveying fluids below ambient temperature with vapor retardant jackets with self-sealing laps. Insulate complete system.
4. For insulated pipes conveying fluids above ambient temperature, secure jackets with a self-sealing lap or outward clinched, expanded staples. Bevel and seal ends of insulation of equipment, flanges, and unions.
5. Provide inserts between support shield and piping on piping 1 to 12-inch diameter or larger. Fabricate of Johns Manville Thermo-12 or other heavy density insulating materials suitable for temperature. Insulation inserts shall not be less than the following lengths:

1-1/2” to 2-1/2” pipe size	10” long
3” to 6” pipe size	12” long
8” to 10” pipe size	16” long
12” and over	22” long

6. For pipe exposed in mechanical equipment rooms or in finished spaces, finish with Manville Zeston 2000 PVC jacket and fitting covers or aluminum jacket.
7. For exterior applications, provide weather protection jacket or coating. Insulated pipe, fittings, joints and values shall be covered with Johns Manville Zeston 2000 PVC or aluminum jackets. Jacket seams shall be located on the bottom side of horizontal piping.

D. External Ductwork Insulation:
1. Provide insulated ductwork conveying air below ambient temperature with a vapor retardant jacket. Seal all vapor retardant jacket seams and penetrations with UL listed tapes or vapor retardant adhesives.
2. Provide insulated ductwork conveying air above ambient temperature with or without vapor retardant jackets. Where service access is required, bevel and seal ends of insulation.
3. Continue insulation through walls, sleeves, hangers, and other duct penetrations except where prohibited by code.
4. The underside of ductwork 24-inch or greater shall be secured with mechanical fasteners and speed clips spaced approximately 18-inch on the center. The protruding ends of the fasteners should be cut off flush after the speed clips are installed, and then, when required, sealed with the same tape as specified above.

E. Exterior Ductwork Installation: Provide 1-inch slope on top of duct between the center of duct and longitudinal edges.

3.12 TESTS

A. General:
1. Power, water and fuel required for tests will be furnished as specified under the General Conditions or General Requirements Sections. Materials, gauges, test thermometers, and labor necessary shall be furnished by this Contractor.
2. Should a piece of apparatus, material, or work fail in these tests, it shall be removed immediately and be replaced by perfect material at the Contractors expense. Replaced portions of work shall be retested. Tests shall be performed in the presence of the Owner’s Representative or Architect.

B. Equipment:
1. After the entire heating, ventilating and air conditioning system installation has been completed, ducts installed, and all dampers adjusted, etc., a complete test of each air conditioning unit shall be made to determine whether the equipment fulfills the guarantee

regarding the quantity of air delivered, efficiency, noiseless operation and other requirements.

2. Contractor shall furnish labor necessary to adjust the operation of the apparatus and make the connections for the test. Contractor shall replace fuses blown during the tests. After the tests, restore connections, apparatus, etc., to their proper condition.
3. Contractor shall demonstrate proper operation of the temperature control system and control system interlocks.
4. Provide Owner with report certifying that systems are operating properly.

3.13 OPERATION

A. Operational Readiness: The Contractor shall insure that the complete installation including equipment and controls, is complete, operating, checked, and adjusted at the time of final inspection. Contractor shall provide and install new filters in units prior to final inspection.

B. The Contractor shall be held responsible for any delays incurred and re-inspections required due to lack of above-mentioned readiness.

C. Each entire system shall be operated continuously for a period of 3 full days, at a time requested by the Owner, to prove that the systems will fulfill guaranteed requirements.

END OF SECTION

SECTION 26 05 00

COMMON WORKS FOR ELECTRICAL

PART 1 - GENERAL

1.01 REFERENCE

A. General: Requirements in Addenda, General /Special Conditions and Division 1, 2, 3 collectively apply to this work.

1. Examination of Site and Contract Documents. Prior to bidding each bidder shall visit the site of the proposed work and to become fully acquainted with the conditions relating to the construction and labor so that full understanding of the facilities, difficulties, and restrictions attending the execution of the work under the contract is obtained. Bidders shall thoroughly examine and be familiar with the drawings and specifications. The failure or omission of a bidder to receive or examine contract documents, forms, instruments, addendums, or other documents, or to visit the site and acquaint himself with conditions there existing shall in no way relieve a bidder from any obligation with respect to their bid or to the contract. The submission of a bid shall be taken as prima facie evidence of compliance with this section.

1.02 DESCRIPTION

A. Principal Work Items are: Provide labor, material and equipment necessary to complete and test the electrical work as shown on the drawings and as specified herein. Work will include, but not limited to the following:

1. Equipment and facilities required by the utility companies to provide temporary and permanent services, including facilities required for installation of the utility company metering, and pay charges required by the utilities company to provide temporary and permanent services except as indicated in the other paragraph below.

2. Underground duct banks and pre-cast concrete pull-boxes/manholes, slab boxes, concrete pads for electric and telephone/fiber utility services.

3. A complete electrical grounding system for the building, including electrical service grounding (Ground Rods in ground well, Ufer ground and cold water pipe) and Low Voltage Communication system reference ground with a single point of ground connection at the Main Ground Bus.

4. Supports, duct spacers, clamps, hangers, fastening devices, sleeves, slots, concrete bases, physical protection, caulking, weatherproofing, sealing, closing, etc.

5. Complete installation and supply of 480/277-Volt and 208/120-Volt, 3-Phase, 4-Wire Switchboard, Distribution Switchboards, Integrated Power Center switchboard, feeders, pull-boxes, distribution transformers, control transformers, motor starters, disconnect switches, panel boards, branch circuit conduit and wiring and all other electrical devices.

6. A complete grounding system for the 480/277-Volt and 208/120-Volt derived systems and all of the electrical equipment.

7. Luminaires (lighting fixtures), including LED driver, specified lamps and electronic ballasts, emergency battery pack (as applicable) or centralized battery inverter and occupancy sensor control or day light control and other control as noted complete and operable.

8. Exterior lighting fixtures including concrete bases for poles or low level area lights, walkway (bollard), step lights, and planter lighting.

9. Electrical work for the mechanical system, except as specified to be furnished or installed as part of other Sections in the Specifications.

10. Distribution materials and connection of the following listed equipment by the specific equipment furnished so that a complete and operable system results:

    a. Building power, communication and fire alarm system.

    b. Electrical operated roll down doors, gates and other type of door operator.

    c. Electrical operated shades system.

    d. Irrigation power connections.

    e. Electrically operated plumbing fixtures.

    f. Nurse Call system.

11. Emergency lighting system, including emergency battery pack units (integral or remote mount unit of the fixture) or centralized battery back-up lighting inverter system, un-switched power branch circuit wiring and connections to 2-circuit exit signs.

12. Furnish and install hangers, anchors, sleeves, chases, access panels and supports required for electrical works.

13. Electrical conduit system rough-in.

14. Complete Fire Detection and Alarm system including control equipment, devices, terminal cabinets, backboards, boxes, conduits, wiring and connections.

15. Complete system of empty conduit, outlets, backboxes, cabinets and/or terminal backboards for the security distribution system or other low voltage /signal systems.

16. Complete system of conduit with voice/data cables, outlets with devices, backboxes, cabinets and/or terminal backboards with terminating blocks or patch panels for voice/data distribution system.

17. Excavation, backfill and concrete works required to complete items of this section.

18. Closing of openings resulting from coring, sleeving, removal of conduit and/or equipment.

19. Cleaning, patching, fire stopping/proofing seal, repairing and painting.

20. Permits and Code Inspection fees.

21. Prime coat painting of electrical equipment exposed to view in public area where required and deemed necessary by Architect.

22. Identification nameplates, instruction plates, tags, labels, magnetic yellow tapes, underground warning tapes and etc. Including Arc-Flash and Shock Hazard Warning Label per NEC and NFPA 70E requirements.

23. Shop drawings and technical data; operating instruction and maintenance manual.

24. Test of equipment and system installed.

25. “As-built” drawings, including but not limited to record of actual routing of duct banks, location of Power Pull-boxes/Manholes and Communication Pull-boxes, lighting and power/communication plan as-built condition.

26. Incidental items not indicated on the drawings nor mentioned in the specifications that belong to the work described, or are required to provide complete systems, as though called out here in every detail.

B. Related Work Described Elsewhere: For detailed description of the electrical work, also see other Sections in Division 26 of these Specifications. Refer to the following Sections of the Specification for related work:

1. Trenching and Backfilling for Utilities: Section 023150.

2. Horizontal Directional Drilling: Section 024130

C. Work in Cooperation with Other Trades:

1. Examine the Drawings and Specifications and determine the work to be performed by the electrical, and other trades. Provide the type and amount of electrical materials and equipment necessary to place this work in proper operation, completely wired, tested, and ready for use. This shall include conduits, conductor, and other devices for the required operation and control sequences of electrical, and other existing systems or equipment.

1.03 SUBSTITUTIONS

A. General: Only written approval of Architect will permit substitutions for materials specified; See Section 012500, Contract Modification Procedures.

1.04 QUALITY ASSURANCE

A. Standards:

1. Comply with standards listed in the following:

a. Underwriters' Laboratories Inc. (UL).

b. The 2013 California Electrical Code, National Electric Code (NEC) 2008 edition, with California Amendments.

c. The USA National Fire Code (NFPA).

d. The National Electrical Manufacturers' Association (NEMA).

e. Institute of Electrical and Electronic Engineers (IEEE).

f. American National Standards Institute (ANSI).

g. 2013 California Code of regulations, Title 24.

2. Off-Site Work: Conform to Governing Agencies requirements.

3. Earthquake Provisions: Electrical components shall be anchored and braced to meet the force and displacement requirements prescribed in the 2010 CBC, Sections 1615A.1.12 through 1615a.1.22 and ASCE 7-05 Chapter 6 and 13.

4. In case of conflict among the reference standards, the more stringent provisions shall govern and shall be resolved before installation at Contractor's expense. Prepare and secure approval for any clarifying details required by inspection authorities.

5. Nothing in the Contract Documents shall be construed as authority to permit work not conforming to codes, ordinances, standards or regulations.

B. Qualification of Installers:

1. Throughout the progress of installation of the work of each Section, provide where required as indicated in respective Sections, at least one manufacturer's authorized representative who shall be thoroughly familiar with the specified requirements, completely trained and experienced in the necessary skills, who shall be present at the job site and shall direct all work performed under that particular Section.

2. Cutting and patching finish work shall be performed by workmen of the proper trade.

C. Qualification of Manufacturers:

1. Manufacturers of the products supplied for this project shall have been in the business of manufacturing the particular product for at least five years and be able to prove a history of successful production acceptable to the Architect. As a condition for approval and when directed by the Architect, submit a list of past projects showing a minimum of five projects of similar scope to the Architect for approval.

2. Provide together with the Shop Drawing submittal, where called for in these Specifications, a list of five projects which shall have been in satisfactory operation for the past five years.

1.05 SUBMITTALS

A. General: Comply with provisions of Section 013000.

B. Samples: Follow procedure under General Conditions. Submit duplicate samples showing manufacturers' standard finishes, colors and textures for all equipment exposed to view.

C. Manufacturers Data: Within 30 calendar days after award of Contract, submit:

1. Complete materials list of all items proposed to be furnished and installed.

2. Manufacturer's specifications and other data required to demonstrate compliance with the specified requirements.

3. Unless specifically called for otherwise, provide bound copies of catalog cuts for standard products, not requiring specifically prepared Shop Drawings, for the following:

a. Conduit and raceways, including fittings, supports, spacers, etc.

b. Junction box and outlet box.

c. Wiring device and face plate.

d. Occupancy sensors and other lighting control components.

e. Conductor and connectors.

f. Underground warning and magnetic yellow tapes.

g. Grounding system components.

4. Where more than one item, size, rating or other variations appear on a catalog cut sheet, clearly identify all items to be provided properly indexed and referenced to Architect's identification numbers, designations and/or details.

5. Provide specially prepared Shop Drawings, including but not necessarily limited to:

a. Switchboard and Distribution Boards.

b. Integrated Power System.

c. Panelboards.

d. Short circuit, Over-current Device Coordination and Arc Flash Hazard Analyses.

e. Manhole/pull box.

f. Typical hardware and accessories lay-out in the manhole.

6. No work shall be initiated or fabrication of any equipment started prior to Architect's return of reviewed submittals.

D. Operating Instructions and Maintenance Manuals:

1. Thoroughly instruct operating personnel designated by the District in the operation and maintenance of the equipment and systems installed.

2. Following approval of Shop Drawings of electrical equipment and prior to acceptance of electrical work, prepare two copies of operating and maintenance manuals in accordance with Section 013300, describing operating, servicing, and maintenance requirements of electrical equipment installed under Division 26 with particular emphasis on safety devices. Operation and Maintenance Manuals shall cover electrical equipment and systems including but not limited to the following:

a. Integrated Power Center.

b. Switchboards and Distribution Boards.

c. Motor Control Center.

d. Lighting Control System.

E. Information contained in the manual for the above equipment shall include the following:

1. Manufacturer's catalog cuts and printed descriptive bulletins.

2. Manufacturer's installation, operating, and maintenance instruction booklets.

3. Parts list and costs.

4. List of recommended spare parts for 12 months' operation.

5. Name, address, and phone number for closet source of spare parts.

6. Wiring and schematic diagram.

1.06 PRODUCT HANDLING

A. Protection: Protect materials before, during, and after installation and protect installed work and materials of all other trades.

B. Replacement: In the event of damage, immediately make all repairs and replacements necessary for the approval of the District’s Representative and/or Architect and at no additional cost to the District.

C. Delivery and Storage: Deliver all materials to the job site in their original unopened containers, where applicable, with all labels intact and legible at time of use. Store in strict accordance with the manufacturers' recommendations as approved by the District’s Representative Inspector.

1.07 PERMITS

A. General: Secure permits and pay all required fees for the installation of the electrical work.

1.08 RECORD DRAWINGS

A. General: Refer to Specification Section 017700, Contract Close-Out, "Project Record Documents", for requirements.

1.09 CERTIFICATES

A. General: Refer to Specification Section 017700, Contract Close-Out, for requirements.

1.10 GUARANTEE

A. General: Refer to Specification Section 017700, Contract Close-Out, "Guarantee for Requirements."

B. Manufacturers Guaranties: Submit guarantees for applicable equipment and devices.

PART 2 - PRODUCTS

2.01 MATERIALS, GENERAL

A. General: See General Conditions, Article titled "Materials".

1. Architect shall be the sole judge of material conformance to Contract Documents. Equal products shall be as selected by the Architect.

2. Materials and products shall be new and in perfect condition, and of the manufacturer's latest type and model. Unless otherwise noted, each material or product type shall be from one manufacturer only.

3. Exterior mounted electrical boxes, devices and miscellaneous items shall be tamper-proof assemblies. Where not a standard feature, shop modify assembly to meet this requirement.

4. Where devices or equipment is referred to or indicated in these documents or on the Drawings in the singular number, such reference shall be deemed to apply to as many such devices as are required to complete the intended installation as specified and/or as shown on the Drawings.

5. In case of conflicts among Drawings and Specifications, the more stringent requirement, larger quantities, better qualities and/or more proper application and installation for the particular situation shall govern.

6. Wherever "finishes" are indicated to be selected by the Architect, such "finishes" shall include all standard as well as optional finishes offered by the Manufacturers.

7. Materials shall be UL listed where applicable.

B. Manufacturer and Catalog Numbers:

1. Where manufacturer and catalog numbers are indicated, the published data on the product by the manufacturer are deemed to be part of this specification.

2. Numbers used indicate basic minimum design and appearance required, and must be modified to meet all specific requirements of Contract Documents.

3. Before submitting bid, verify availability of such modification. Where manufacturers cannot meet these modifications, notify Architect 10 days prior to bid date and deem these products removed from approved list of equipment.

4. Act of submitting bid is certification that all equipment specified, with required modifications, is available from at least one manufacturer listed.

2.02 CONDUIT

A. General: Provide only new conduit with UL listing or label and deliver to the site in standard lengths.

B. Types:

1. Rigid Steel Conduit and Couplings: Hot-dipped galvanized or sherardized inside and out, with galvanized threads. Electro-galvanizing is not acceptable. Provide insulated throat metallic bushings.

2. Rigid Plastic Conduit: Extrude from virgin polyvinyl chloride compound, Schedule 40 heavy wall, in 10-foot lengths with couplings. Where threaded connection is required, provide Schedule 80 conduit.

2.03 GROUND ROD

A. Ground Electrode:

1. Install a grounding electrode constructed of 3/4-inch diameter by 10-foot long copper-weld rod driven vertically full length into the ground through the ground well.

2. Fill the inside of the ground well with a layer of fine sand and layer of crushed rock on top with the ground rod protruding approximately 3-inch above the two layers.

B. Acceptable Manufacturers: Provide J.A. Weaver W-3410 for the grounding electrode

PART 3 - EXECUTION

3.01 MATERIALS AND WORKMANSHIP

A. General:

1. Materials and equipment shall be installed in accordance with approved recommendations of the manufacturer and conforming to the Contract Documents. Devices and equipment are laid out per requirements of one manufacturer. Modify work and arrangements to suit actual equipment installed and pay for all additional cost incurred, if any. The installation shall conform to the applicable codes, rules, and regulations. The Drawings indicate, in diagrammatic form, the work to be done rather than exact routing, location and arrangement of equipment, conduit, and wiring. Make use of data in Contract Documents, verify against developed field conditions, install work in an orderly arrangement in a manner to overcome structural and other interference.

2. Study all Drawings and properly locate the outlets and equipment so that they are readily accessible. Locate equipment and outlets to avoid interference with mechanical or structural features. Do not support any electrical material, equipment or device from sheet metal roof decks or ductworks. If any conflicts occur necessitating departures from the Drawings, details of such departures and reasons therefore shall be submitted as soon as practicable for written approval.

3. Where developed conditions make revisions necessary to indicated locations and arrangements, Contractor shall make changes, at no additional cost, provided:

a. Change is ordered prior to time conduit is installed.

b. Length of conduit run is not changed more than 10%.

4. Architectural and structural drawings take precedence over electrical drawings in representation of general construction work, and drawings of various trades take precedence in representation of work of these trades. Refer to all Contract Documents and coordinate electrical work with other work.

5. Where discrepancies arise among the various Contract Documents, stop work in affected areas. Promptly notify Inspector of conditions.

6. Galvanic and chemical corrosion shall be prevented by isolating dissimilar metals and preventing contact of aluminum with concrete, plaster, mortar or earth.

7. All equipment shall be braced and/or anchored to meet the force and displacement requirements prescribed in the 2013 CBC.

8. The bracing and attachments to the structure shall be detailed on the approved drawings or they shall comply with one of the OSHPD pre-approvals (OPA #) as modified to satisfy anchorage requirements of ACI 318, Appendix D.

9. The Structural Engineer of Record shall verify the adequacy of the structure to support the hanger and brace loads

3.02 WIRE AND WIRING METHODS

A. General:

1. Wiring and cable for all systems including low voltage, control circuits, and communication systems shall be installed in conduit or raceway unless otherwise noted.

2. Before installing conductors, remove debris and moisture from conduit and equipment enclosures. Use linseed soap, minerallac or other specifically approved wire pulling compound to facilitate the installation of conductors. Oil, grease or similar substances shall not be used as pulling compound.

3. Each circuit shall correspond to the branch circuit number or control circuit number as indicated. All control wiring shall conform to the wiring diagrams on the Drawings when indicated or as directed by Owner’s Representative, and the manufacturer's wiring diagrams; and shall control the equipment in the manner specified under this and other Sections.

B. Splices:

1. Make joints, splices, taps and connections for 600-Volt conductors with solderless connections. Use only plated copper alloy connectors or lugs; aluminum connectors or lugs are not acceptable.

2. For copper conductors, the following connections are acceptable:

a. For #10 AWG and smaller: Use 3M "Scotchlok" or Ideal "Super Nut".

b. For #8 AWG and larger: Use T & B "Lock-Tie" connectors, Burndy Versitaps and heavy-duty connectors, or O.Z. solderless connectors.

3. Re-tighten all bolt type connectors 24 to 48 hours after initial installation and before taping.

4. Tape all connections made with non-insulated type connectors with rubber-type tape, 1-1/2 times the thickness of the conductor insulation, then cover with Scotch No. 33 tape.

C. Color Coding: Color code all feeders by means of factory color coded conductors. Each phase shall be the same color throughout the system and shall be a different color from other phases and other systems. The identified grounded neutral conductor shall be white, ground shall be green. Color coding for branch circuit wiring shall be per applicable codes and shall match those existing.

D. Tagging:

1. Neatly arrange and lace conductors in switchboards, panelboards, gutters and terminal cabinets by means of nylon twine, Scotch No. 33 tape, or T & B "Ty-Rap" ties.

2. Main and feeder cables shall be tagged in all boxes, panels, wireways, gutters and at terminal blocks. Tags shall identify where power source originates from, wire or cable number and equipment served and shall be made of flame resistant material.

3. Tag wires for future use and tape exposed ends in same manner as required for non-insulated connectors.

E. Voltage Drop: All branch circuits shall be limited to a maximum voltage drop of 2-1/2%. Increase branch circuit wire sizes where required to comply with this requirement. All feeders shall be limited to a maximum voltage drop of 1-1/2%.

3.03 CONDUIT AND TUBING

A. General:

1. Provide the type of conduit permitted in these Specifications or required for each location or condition per applicable codes and jurisdictions whichever is more stringent.

2. Where conduit penetrates fire-rated walls or floors, provide pipe sleeve two sizes larger than conduit; pack void around conduit with oakum and fill ends of sleeve with fire-resistive compound. Provide mechanical fire-stop fittings with UL listed fire rating equal to wall or floor rating. Seal opening around conduit with UL listed foamed silicone elastomer compound.

B. Conduit Usage:

1. Concrete or masonry in contact with earth and concrete block walls are not considered as dry locations.

2. Rigid plastic conduit, PVC Schedule 40, may be used only underground and below slabs on earth.

3. Use rigid metal conduit where Code required; where indicated as hazardous area; where exposed to the weather; where exposed at less than 7'-6" above the floor in areas accessible to anyone other than authorized operating or maintenance personnel; where underground; and where other types of conduits are not allowed in this Specification.

C. Supports:

1. Support conduit at Code required intervals as a minimum. Provide additional supports where required or as directed by the Architect.

2. Suspended conduit: Use malleable iron factory-made split-hinged pipe rings with threaded suspension rods sized for the weight to be carried (minimum 3/8-inch diameter), Kindorf or equal. For grouped conduits, construct racks with threaded rods and tiered angle-iron or unistrut cross members. Clamp each conduit individually to a cross member. Where rods are more than 12-inch long, provide rigid sway bracing.

3. Wherever conduit may be affected by movements of the supporting structures or medium, and where secured on both sides of building control joints, provide suitable flexible or expansion devices.

4. Conduits or pipe shall not be welded to steel structures.

D. Locations:

1. Route conduit to avoid drains equipment hatch, other gravity lines and all obstructions. Where conflicts occur, relocate conduit as required.

2. Keep conduit at least 6-inch from the coverings on hot water pipes; at least 18-inch from the covering on exhaust flues and breechings; and at least 24-inch from radiant heaters.

3. Where exposed conduit runs are permitted, run conduit parallel with or at right angles to structural members, walls or lines of the building. Route exposed conduit to preserve headroom, access space and work space.

4. Changes in direction of runs shall be made with symmetrical bends or cast metal fitting. Field-made bends and offsets shall be made with an approved hickey or conduit-bending machine. Bending radius shall not be less than those allowed in the NEC. Crushed or deformed raceways shall not be installed or when installed, shall be changed as directed by the Architect.

5. Conduit may be run in concrete members or slabs only with previous written permission of the Architect. Individual written permission shall be obtained for each conduit run or for conduits within each definitive area or for each particular condition.

E. Joints, Bends and Fittings:

1. Where conduit is underground, under slabs or grade, exposed to the weather, or in wet locations, make joints liquid tight and gas tight. Seal conduit entries with silicone sealant.

2. Threaded Conduit: Use red lead and oil applied to the male threads only and tighten joints securely. For underground or under slab conduits, apply a heavy coat of Pabco P & B No. 2 paint after installation to surfaces within 6" (150 mm) on both sides of fittings and to areas where wrenches or other tools have been applied. On exposed conduits, repair scratches and other defects with galvanizing repair stick, Enterprise Galvanizing "Galvabar", or equal.

3. Plastic Conduits: Use approved solvent-weld cement specifically manufactured for the purpose.

4. Bushings shall be installed on ends of all conduits and shall be of the insulating type where required by applicable codes.

5. Cut threads on rigid conduit to standard taper and to length such that bare metal exposed by the threading operation will be completely covered by the couplings or fittings used. In addition, cut the lengths of the thread such that joints will become secure and wrench tight before conduit ends butt together in couplings and before conduit ends butt into the ends or shoulders of other fittings. Securely tighten threaded connections.

6. Keep bends and offsets in conduit runs to an absolute minimum. For the serving utilities, make large radius bends to meet their requirements. Replace deformed, flattened or kinked conduit.

7. Rigid metal conduit of 1-1/4-inch trade size or larger: Provide large radius factory-made bends or field bend the conduit with a power bender designed for the purpose and utilizing bend forms sized for the conduit being bent.

8. Plastic Conduit: Apply heat for bends so that conduit does not distort or discolor. Use a spring mandrel as required ensuring full inside diameter at bends.

9. Bend conduit to radius no less than Code required minimum.

10. For conduits entering or leaving hazardous areas, provide each conduit at point of entry and exit from such areas with sealing inlets whether indicated on Drawings or not. Fill each inlet with approved sealing compound.

F. Underground Conduits and Duct Banks: Make installation in accordance with Section 260545.

G. Conduit Stub-outs:

1. Unless otherwise indicated, all conduit stub-outs shall be minimum 4 or 5-inch as indicated in diameter and underground.

2. Extend underground conduit stub-outs a minimum of 5-foot clear beyond building foundations, concrete walks, paving, other utilities and the like. Keep underground conduits a minimum of 10-foot clear of future building locations where indicated.

3. Leave ends of underground stub-outs 6-inch clear of concrete envelope. Cap ends of steel conduit and wrap entire exposed portions with Scotchrap No. 50. Plug ends of nonmetallic conduit with Duxseal and cover with gravel and redwood planks for mechanical protection.

4. Exact locations of stub-outs shall be indicated by a brass marker at finished grade and on Record Drawings.

H. Conduit Stub-ups:

1. Use rigid steel conduit for stub-ups, 90-degree bends and risers to grade from other conduits. Stub-ups designated for future use shall be capped.

2. Conduits stubbed up through concrete floors for connections to freestanding equipment shall be provided with a short elbow and an adjustable brass top or flush floor coupling set flush with the finished floor. Wiring shall be extended in rigid threaded conduit to the equipment, except that where required, flexible conduit to the equipment, except that where required, flexible conduit may be used 6-inch above the floor. Screwdriver-operated threaded flush plugs shall be installed in conduits from which no equipment connections are made. Use oil or grease on top of coupling and in threads on plug to prevent sticking.

3. In utility rooms, electrical rooms, mechanical rooms and other unfinished areas not accessible to the public, terminate stub-ups to a minimum of 8-inch above floor unless otherwise indicated.

I. Empty Conduits:

1. Provide a nylon or polyethylene rope rated 250-lb tensile strength in each conduit more than 10-foot in length and left empty for future use. Not less than 10-inch of slack shall be left at end of the conduits.

2. Tag empty conduit at each accessible end identifying the purpose of the conduit and the location of the other end.

3. In wet, corrosive, outdoor or underground locations, use brass, bronze or copper No. 16 gauge tags or lead tags secured to conduit ends with No. 16 or larger galvanized wire. Inscribe on the tags with steel punch dies clear and complete identifying information.

4. In dry interior locations use metal-rimmed paper tags securely affixed with nylon twine. Inscribe on the tags with India ink, clear and complete identifying information.

5. Unused conduit openings shall be plugged or capped with a suitable device designed for the purpose. Caulking compound shall not be used for plugging empty conduits.

3.04 PENETRATIONS

A. General: Penetrations in walls, floors or ceilings requiring protected openings shall be fire-stopped. Fire-stopping shall be of an approved material, securely installed and capable of maintaining its integrity when subjected to the time-temperature curve of State Fire Marshal Standard 12-43-3 and Standard 12-43-1. Manufacturer's instructions shall be made available to the inspection authority and kept at the job site.

3.05 MEMBRANE PENETRATION

A. General: Where penetration through membrane cannot be avoided, cut and re-seal membrane at point of penetration as required.

3.06 PAINTING AND FINISHING

A. General: Paint all electrical equipment exposed to view in public areas with one coat of primer. Finish coat painting will be provided under Section 09900. For equipment inside electrical room, mechanical room and utility closets accessible only to authorized maintenance personnel, standard manufacturer's finishes are acceptable.

3.07 GROUNDING

A. General:

1. Ground the neutral of each isolated AC or DC system having a neutral conductor with a system ground connection sized as indicated on the Drawings or per appropriate code requirement when not indicated. Ground clamps shall be readily accessible.

2. Resistance to ground shall not exceed 5-Ohm.

B. Ground Well:

1. In the event that a metallic cold water pipe system is not available or should the grounding system to the cold water line not provide the proper ground resistance as specified, install single or multiple ground wells to obtain the proper resistance.

2. Locate ground rods a minimum of 6-foot apart or as indicated. Connect rods with minimum #4/0 AWG stranded, medium-hard drawn bare copper ground wires. Install ground wires 6-inch below slabs or 18-inch below finished grade, laid slack and in contact with earth throughout. Make buried tapes or splices by an exothermic welding process, "Cadweld" (by Erico) or Burndy "Thermoweld", and connect to the rods with Burndy type GK connectors.

3. Longer ground rods driven to a greater depth may be used in lieu of additional ground wells or in conjunction with other ground wells to attain the specified ground resistance.

4. Provide a white colored insulated copper conductor in a rigid steel conduit from the system grounding points to the grounding electrode in the ground well. Connect the conductor to the electrode with a 2 bolt "Evedur" clamp.

5. Locate ground wells where accessible for inspection, maintenance and testing.

C. Equipment Ground:

1. Use the conduit system for equipment and enclosure grounding where separate ground wire is not specified.

2. Where nonmetallic conduits are used, provide a green color insulated copper ground conductor, of legal size, within the conduit and terminate properly to the equipment enclosures at each end. Enlarge size of conduit as required per applicable code(s).

3. Provide bonding devices, fittings or jumpers at expansion fittings or wherever continuity of grounding is not certain or where required by authorities having jurisdiction.

4. Provide, whether indicated on Drawings or not, each power feeder, single and multi-wire branch circuits (except those serving lights) with a separate green insulated ground wire, size as required by NEC, together in the circuit conduits and connect to the devices. Enlarge conduits where necessary to accommodate the ground wire. Conductor shield approved by conductor manufacturer may be used in lieu of a separate ground wire.

3.08 TESTS

A. General: In addition to tests required by other sections, perform or cause to be performed in the presence of the Architect, all tests specified for electrical work when the work is substantially complete.

B. Ground Resistance Test:

1. Employ a firm, qualified in such work, to measure resistance to grounding electrodes. Firm shall be approved by the Architect. Make tests before concrete is placed in affected areas in order that corrective measures, if required, may be taken.

2. Test to demonstrate that the insulation resistance between phase conductors and ground to be not less than requirements of Title 24. All circuits shall be tested for neural connections.

3. Test to demonstrate that the entire raceway, boxes and metallic enclosure system maintain electrical continuity and that the maximum resistance measured from any point on the system to a grounded point of reference does not exceed 5-Ohm.

4. Submit to the Architect, a report showing the results of these measurements.

5. If the resistances do not comply with the requirements of these Specifications, perform all corrective measures as directed by the Architect.

C. Test of each duct for blockage or deformation after concrete has cured for 24 hours. Use a flexible mandrel/scrapper not less than 12-inch long with a diameter approximately 1/4-inch less than the inside diameter of the duct, pull a mandrel behind a stiff bristles brush.

1. Replace any duct section found blocked. Notify District Inspector 10 days before duct tests; submit written reports of tests to District Inspector.

D. Service Voltage Test:

1. Measure the service voltages under no load and under maximum load conditions.

2. Submit to the Architect, a report showing the results of these measurements.

3. If, in the opinion of the Architect, the voltages regulation are not within acceptable limits make and complete arrangements with the utility company and/or other concerned agencies for proper electrical service.

E. Operating Test: Upon completion of the work and adjustment of equipment, conduct an operating test and submit for approval at such time as the Architect directs. Conduct the test in the presence of the Architect and the District Inspector. Demonstrate systems and equipment to:

1. Operate in accordance with requirements of the Contract Documents.

2. Be free from electrical and mechanical defects.

F. Other Tests: Conduct all other and additional tests to assure the Architect that the electrical work is free from short circuits, grounds (ground faults) other than intentional grounds, and defective or damaged insulation. In additional, perform all tests that are required by authorities having jurisdiction or are requested by the Architect.

G. Cost: All cost incurred, including required instruments and personnel for the tests shall be included on the bid price and paid for by the Contractor.

3.09 CLEANING

A. General: Periodically remove waste and rubbish and maintain order. Clean and polish finished metal surfaces. Exposed materials, equipment and apparatus shall be thoroughly cleaned of dirt, rust, cement, plaster, etc., and have cracks and corners scraped out clean, and surfaces carefully cleaned of grease and oil spots and be left smooth and clean, with unfinished surfaces ready for painting. Clean grease, oil and other foreign substances from floors, walls, ceilings and fixtures, and leave premises clean and free from debris and unused construction materials, where caused by work under this Section. Completely clean insides of lighting fixtures removing dirt, bugs and other foreign substances.

3.10 COORDINATION

A. General: Coordinate with each trade involved in the construction project. Work shall be fully laid out in advance, coordinating all features of construction, including control wiring between different systems.

3.11 QUALITY CONTROL

A. General: Establish and maintain quality control for operations under this Section to ensure compliance with Contract requirements, and maintain records of quality control for all materials, equipment and construction operations.

3.12 INSPECTION

A. Preparatory inspection shall be conducted prior to commencing work, as follows:

1. Check to see that required shop drawings and other submittals have been made, are complete, and approved. Where exceptions have been taken to submittals, but approved subject to correction, check to verify that proper corrections have been made.

2. Check materials and equipment upon delivery at job site for compliance with approved submittal. Verify for proper storage.

3. Check layout drawings and details of interfaces with existing work, with interfaces and interrelations with work under other Divisions of the Specifications, and with interfaces with work performed.

4. Check the actual conditions on the site for conformance with the above. Verify that conditions are ready for new work.

5. Review installation procedures and code requirements with each person involved in inspecting and performing the work.

6. Review requirements of Drawings, Specifications, and the manufacturer's requirements and recommendations. In the event clarification or the Architect's decisions are required, such shall be obtained before proceeding with the work.

7. Quiz personnel doing work to ensure their understanding of Contract requirements including workmanship and techniques.

8. This inspection and the results thereof shall be recorded. Inspection records shall be made available for review by the Architect and the District Inspector at any time upon request.

B. Initial inspection shall be conducted when a representative sample of the work is complete, as follows:

1. Review the representative sample of the work against the Specification and code requirements previously discussed at preparatory inspection. Review shall include, but is not to be limited to:

a. Layout and sub-grade work.

b. Conduit/raceway installation.

c. Equipment installation.

d. Grounding.

e. Manholes, hand holes, junction boxes, enclosures, etc.

2. Note and discuss deficiencies observed and corrective action to be taken. If corrective action is to be taken, an additional inspection shall be conducted for compliance.

3. This inspection and the results thereof shall be recorded. Inspection records shall be made available for review by the Architect or the District Inspector at any time upon request.

C. Follow-up inspections shall be conducted daily to ensure compliance with corrections required by initial inspection, as follows:

1. Check completed work against corrected representative sample of work.

2. Perform tests required by Contract to ensure compliance.

3. This inspection and the results thereof shall be recorded. Inspection records shall be made available for review by the Architect or the District Inspector at any time upon request.

D. Copies: Furnish the Architect a copy of these records and tests, as well as records of corrective action taken.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Identification for conductors and communication and control cable.

2. Warning labels and signs.

3. Equipment identification labels.

1.2 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Marker Tape: Vinyl or vinyl -cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.2 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 x 10-inch.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 x 14-inch.

E. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

F. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Dimension in first subparagraph below is clear space prescribed in NFPA 70 (2002 Edition), Table 110-26(A)(1), for equipment with nominal voltage to ground of 151 to 600-Volt, and with grounded parts, including concrete, brick, or tile walls, opposite the equipment. Additional clear space is required at this voltage if there are unguarded exposed live parts on both sides of the workspace. Retain below and revise to suit Project conditions or requirements of authorities having jurisdiction, or indicate varying clearance requirements on Drawings.

3. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

4. Equipment containing or operating circuits more than 240-Volt nominal: Provide laminated plastic warning signs engraved in 1/2-inch high x 3/8-inch wide white letters on red background to read: “CAUTION HIGH VOLTAGE-XXX VOLT”, XXX indicating actual voltage.

5. Provide Arc Flash Name plate with PPE category information on each serviceable electrical equipment, which required maintenance and or calibration, including but not limited to Switchboards, Transformers, Disconnect Switches and Panels. PPE level shall be in accordance with the Arc Flash Hazard Analysis report done on the Short –circuit and Over-current device Coordination study

2.3 EQUIPMENT IDENTIFICATION LABELS

A. Provide laminated plastic warning signs engraved in 1/2-inch high x 3/8-inch wide white letters on red background. Contractor must comply with NFPA 70 (2002 Edition), Article 110-22, "Identification of Disconnecting Means." Note that, unless otherwise indicated, the labeling products selected below will also be used for labeling that is not required by NFPA 70 but may be specified in Part 3 "Application" Article to identify equipment other than disconnect devices. See Evaluations.

B. Provide three layers laminated plastic (micarta) nameplates engraved in 1/4-inch (minimum) high black letters on white background to correspond with the designations on the Drawings, electrical equipment nameplate shall be as follows:

1. The main nameplate shall give the equipment designation in 1/2-inch high letters, the second line in 1/4-inch high letters shall indicate the Amperage, Voltage-Phase, and Wire. The third line of same dimensions as the second line shall indicate where the equipment fed from. Following is an example of Panelboard nameplate:

PANEL “CHA”
225AMP, 480/277-VOLT, 3-PH, 4W
FED FROM “MS”

C. Provide red letters on white background for emergency equipment.

PART 3 - EXECUTION

3.1 APPLICATION

A. Auxiliary Electrical Systems Conductor and Cable Identification: Use marker tape to identify field-installed alarm, control, signal, sound, intercommunications, voice, and data wiring connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and cable pull points. Identify by system and circuit designation.

2. Use system of designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

B. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply metal-backed, butyrate warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. 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.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

C. Coordinate paragraph and subparagraphs below with electrical Sections in Divisions 26, 27, and 28. Delete items not in Project.

D. Equipment Identification Labels (name plates): On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

a. Indoor Equipment: Provide laminated plastic nameplates engraved in black letters on white background, attached with rivets or self taping screws or with nuts and flat and lock washers.

b. Outdoor Equipment: Engraved, laminated acrylic or melamine label, drilled for screw attachment.

c. Elevated Components: Increase sizes of labels and legend to those appropriate for viewing from the floor.

d. Provide engraved branch circuit breaker numbering strip, screw or riveted on branch circuit and lighting panelboard internal trim. Permanent engraved numbering on internal trim is acceptable, sticker numbering system is not permitted.

e. Provide load schedules for all branch circuit and lighting panelboards, identifying type, size and location of load. Schedules shall be typewritten and protected by transparent plastic cover.

2. Equipment to be Labeled:

a. Identification labeling of some items listed below may be required by individual Sections or by NFPA 70.

b. Panelboards, electrical cabinets, and enclosures.

c. Electrical switchgear and switchboards.

d. Transformers.

e. Substations.

f. Generators.

g. Motor-control centers.

h. Disconnect switches.

i. Enclosed circuit breakers.

j. Motor starters.

k. Push-button stations.

l. Power transfer equipment/MV Switches.

m. Contactors.

n. Pull boxes.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Coordinate first paragraph below with Drawings.

C. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

D. Apply identification devices to surfaces that require finish after completing finish work.

E. Retain paragraph below if self-adhesive identification products are specified.

F. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

G. Retain paragraph below for nonadhesive signs or labels.

H. Attach non-adhesive signs and plastic nameplates with rivets, or screws and auxiliary hardware appropriate to the location and substrate.

I. Retain paragraph and subparagraphs below if color-coding of power and lighting conductors for voltage level identification is required to satisfy the Code, authorities having jurisdiction, or special Project requirements. If retaining, coordinate with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables" and edit to indicate extent of color-coding required. Below applies only to phase conductors. Color-coding of grounded and grounding conductors is dictated by the Code.

END OF SECTION

SECTION 26 24 00

BUILDING SERVICE AND DISTRIBUTION

PART 1 - GENERAL

1.1 REFERENCE

A. General: Requirements in Addenda, General/Special Conditions, and Division 1, 2, 3, collectively apply to this work.

1. Examination of site thoroughly prior to bidding in a requirement of bid submittal.

1.2 DESCRIPTION

A. Work Included: Provide labor, material, equipment, necessary testing, and complete the building service and distribution system as shown on the Drawings and as specified herein.

B. Related Work Described Elsewhere:

1. For detailed description of the electrical work also see other Sections in Division 26.

1.3 SUBSTITUTIONS

A. General: Only written approval of Architect will permit substitutions for materials specified; See Section 007313, Supplementary Conditions for procedure.

1.4 QUALITY ASSURANCE

A. General: As specified in Section 26 05 00.

1.5 SUBMITTALS

A. General: Comply with the provisions of Section 01330 and as specified in Section 26 05 00.

1.6 PRODUCT HANDLING

A. General: As specified in Section 26 05 00.

PART 2 - PRODUCTS

2.1 CONCRETE PULL BOXES

A. General:

1. Provide precast concrete pull boxes where pull boxes are indicated complete with cover, drain hole and two pull irons. Unless otherwise indicated, inside dimensions for pull boxes shall be 2'-6" wide by 4' long by 4' deep.

2. Pull boxes shall meet legal requirements as to size for conduits terminating therein.

3. Reinforced concrete shall be Class A, 3,000-psig type.

B. Covers:

1. Covers shall be concrete with a cast-iron lid and frame.

2. Cast-iron lid shall have bead weld designation; "ELECTRICAL", "HIGH-VOLTAGE", "COMMUNICATIONS" etc., as required. Submit to the Architect for review.

3. Provide traffic-type construction with traffic covers in areas involving vehicular traffic.

C. Acceptable Manufacturers: Pre-cast concrete pull boxes shall be Quikset EPB-2100 Series or equal by Brooks Products.

2.2 CABLES

A. General: Provide all cables as indicated and specified.

B. 600-Volt Class and Under: Provide conductors of the 600-Volt class and under as specified under paragraph, "Wire and Cable", in Section 260500.

C. Over 600-Volt Class: Refer to Section 261300.

D. Auxiliary Systems: Provide clock, voice/data, security, fire alarm or other auxiliary type system cables as specified under the respective sections.

2.3 INTEGRATED POWER CENTER

A. General

1. Integrated power center (IPC) combine power distribution and controls into one integrated package.

2. The IPC structure is 84-inch high x10-9/32-inch deep load conductors exit the top or bottom of the IPC.

3. The IPC consist of 480Y/277V main circuit breaker, 3-phase 480 Delta – 208Y/120V transformer assembly, 208Y/120V panelboard.

4. The IPC equipment ratings are indicated in the single line diagram.

B. Standard

1. The integrated power center shall be manufactured and tested to meet the following standards: UL 50, UL 67, UL 98, UL 489, UL 891, NEMA AB1, NEMA PB1, NEMA PB2, NEMA 250, NEC Art 384, NFPA 70.

2. The integrated power center and the devices within shall be manufactured and tested to meet the following federal specifications: W-C 375B/Gen, W-C 865C, WP 115B Type 1, Class 1.

C. Enclosure

1. The IPC enclosure shall be NEMA3R floor standing in 4” concrete pad grounded in accordance with NEC for system and equipment ground.

2. Enclosure shall be steel construction in accordance to applicable UL standards.

D. Main circuit breakers

1. Main circuit breakers rating and short circuit duty are as indicated.

2. Refer to standard for compliance.

E. Transformer

1. Three phase, 480 Delta – 208Y/120V. KVA as indicated.

2. H-220C insulation with 150°C. rise.

3. Provision for close coupling to integrated power center line-up.

4. Copper winding.

5. Energy efficient (EE) lighting transformers.

6. Electrostatic shield.

7. UL listed under file E8681.

F. Power Panelboard

1. 208Y/120V. 3-phase 4-wire, with main circuit breaker.

2. Refer to single line diagram for trip and frame size.

3. Refer to standard for compliance.

G. Integrated System

1. Power panelboards shall be installed in common-depth and front-accessible switchboard enclosures.

2. Factory installed power cables shall electrically connect main breaker, transformer and panelboard in the line-up.

H. Fronts

1. Trim front shall meet strength and rigidity requirements or applicable UL standards.

2. Each section shall have a hinged door with a three-point latch with locking provisions.

3. A clear plastic directory card holder shall be mounted on the inside of the door.

4. Locks shall be cylindrical tumbler type. All lock assemblies shall be keyed alike. One key shall be provided with each lock.

I. Acceptable manufacturers: Integrated power center shall be Square D, Cutler-Hammer or General Electric.

2.4 PANELBOARDS

A. General:

1. Provide flush or surface mounted panelboards with main breakers or lugs, sub-fed lugs, bus size and circuit breakers of a rating as shown on the Drawings.

2. Top of panelboard shall not be higher than 78-inch above finished floor.

3. Space for controls such as time clocks, time controlled relays and air-conditioning controls shall be located in a separate compartment with hinged doors within respective panelboards. Where limited by the height of the panels, locate controls in a separate cabinet adjacent to the respective panelboard.

B. Bus bars shall be rectangular in cross-section constructed of copper with silver-plated joints and interconnections. Unless otherwise indicated, neutral buses shall be full size. Bus bars shall be isolated from wiring troughs and working spaces and be braced to withstand a minimum short circuit fault of 25,000-Amps RMS symmetrical or larger as indicated. Provide split bus where indicated on the Drawings.

C. Circuit Breakers:

1. Circuit breakers shall have interrupting capacities as indicated on the Drawings. Minimum interrupting capacities for 120/208 and 277/480-Volt circuit breakers shall be 10,000-Amps and 14,000-Amps RMS symmetrical respectively. Provide breakers of the bolt-on molded case type. Plug-in types are not acceptable.

2. Single-pole breakers shall be full module size; two poles shall not be installed in a single module. Multi-pole circuit breakers shall be of the common-trip type having a single operating handle and for sizes of 50-Amps or less, may consist of single-pole circuit breakers permanently assembled at the factory into a multi-pole unit.

3. Circuit breakers used for motor-circuit disconnects and not in sight of the motor controller shall be capable of being locked in the open position.

4. All circuit breakers shall have provisions for lock out clips which shall be provided for breakers serving motors, signal systems and air-conditioning controls, and as indicated on the schedules on the Drawings.

5. Provide approved "Lock-Off" devices for circuit breakers serving lighting circuits without local switching.

6. Circuit breakers shall be arranged in the panels to correspond exactly with the schedules on the Drawings. Circuit numbers shall be black-on-white plastic tabs or other such permanent type which cannot be changed readily from the front of the panel.

7. Breakers serving loads comprised of large wattage incandescent lamps shall be equipped with desensitized magnetic trip mechanisms which prevent tripping by in-rush currents.

8. Provide approved handle ties for individual circuit breakers protecting each ungrounded branch circuit conductor of multi-wire branch circuits.

9. Provide ground fault circuit-interrupter for all Code required lighting or receptacle circuits rated at 15, 20, 25 or 30-Amps at 120-Volt or above. The bolt-on molded-case type circuit breaker, similar to General Electric Type THQB-GF, shall be of the quick-make, quick-break operating mechanism with construction as described above and with the following additional features:

   a. Amperes line-to-line, ground fault conditions: 0.005

   b. Amperes, symmetrical RMS at 120-Volts: 10,000

   c. Push-to-test circuit.

   d. Trip-free handle to allow breaker to trip even if handle is held or blocked in the "ON" position.

   e. If the above requirements cannot be met, the following shall be provided:

      1) Provide ground fault circuit-interrupter for all Code required circuits. Ground-fault protection shall consist of a ground-sensor encircling all phase conductors, connected to a solid-state ground relay which initiates tripping of the circuit breaker.

      2) Ground protection shall be adjustable from 5 to 50-Amps. Circuit-interrupter shunt-trip and relay shall operate from a 120-Volt control source. Time-current characteristic shall provide 0.1-second operation at about 10 times pickup. Relay shall be surface mounted in a separate barriered space.

D. Control Devices: Contactors, relays, time switches and related equipment shall be as specified in Section 260500 and shall be mounted in a separate barriered space. Refer to the paragraph, "Cabinets", herein.

E. Cabinets:

1. Back boxes shall be flush or surface mounted as shown on the Drawings. Construction shall be of Code gauge zinc-coated sheet steel bearing the UL label where required. Back boxes shall be galvanized when recess mounted. Refer to "Painting" section for finish requirement of galvanized surfaces.

2. Panelboards shall be minimum 20-inch wide and shall be of types as required by the schedules and these Specifications. Where specifically indicated on the Drawings, provide UL listed column-type panelboards. All other requirements of the column-type panelboard shall comply with those specified in this section.

3. Panelboard doors shall be hinged and have pin tumbler cylinder locks operated by paracentric type keys. Panelboard locks shall be common keyed. Furnish two keys for each panelboard.

4. Where more than one door is mounted on a panelboard, arrange the trim so that a minimum 2-inch solid metal trim space is maintained between doors. Doors and trims shall be minimum 12-gauge steel.

5. Provide 12-inch high gutter where double lugs are required or where cable size exceeds bus size.

6. Wiring gutters on panelboards having through feeders shall be 5-inch minimum. Gutters shall be an integral part of the panelboard.

7. Provide barriered space for mounting contactors and control devices with a hinged door and lock, where shown or required.

F. Finish: Doors, trims and surface mounted back boxes located in areas exposed to public view shall be painted with one coat zinc chromate and one coat of primer sealer. Finish painting shall be in accordance with section, "Painting". Provide doors, trims and surface mounted back boxes located in custodian's rooms, mechanical rooms, electrical rooms and other areas not exposed to public view with one coat zinc chromate and a hammertone or light gray baked enamel finish.

G. Identification:

1. Provide neatly typed circuit index cards, clearly and correctly identifying all circuits, mounted in card holders, behind glass or heavy plastic on the inside of the panelboard doors. Indexes shall accurately record all room numbers.

2. Provide nameplates as specified under paragraph, "Nameplates", in Section 260500. Designate the identifying nomenclature, voltage and phase of the panel as shown on the Drawings; for example, "PANEL T3LA, 208/120 VOLT, 3 PHASE, 225 AMPERE BUS".

H. Acceptable Manufacturers: Panelboard assembly, devices and major components shall be of the same manufacturer. Acceptable manufacturers are Square D; General Electric; or Cutler Hammer.

2.5 DISTRIBUTION SWITCHBOARDS

A. General:

1. Provide distribution switchboards with ratings, components and features as indicated on the Drawings.

2. Switchboards shall consist of molded case thermal magnetic circuit breakers or externally operable quick-make, quick-break fused switch as indicated on the Drawings, in floor-standing, dead front, totally metal enclosed sections requiring front access only.

3. Sections shall be nominal 90-inch high, 15-inch deep and 38 or 42-inch wide and shall not exceed the physical spaces allowed for on the Drawings. Switchboards shall be constructed of Code gauge sheet steel.

4. In outdoor locations or where indicated, provide weatherproof enclosure having doors with padlocking facilities.

B. Bus bars:

1. Bus bars shall be rectangular in cross-section, constructed of copper with silver-plated joints and full-height in each vertical section with horizontal cross bus bars between sections. Short circuit bracing capabilities shall be in accordance with the minimum requirement as indicated for the circuit breakers.

2. Provide all lugs for sizes No. 6 AWG or larger suitable for copper conductors. Shop drawings must show lug sizes based on the actual conductors to be provided.

3. Neutral bar shall have terminals for all active, spare or inactive circuits.

C. Disconnect Devices:

1. Circuit breakers shall be of the bolted-on molded case type, with thermal magnetic trips and shall be rated at the voltage with frame sizes, number of poles, and trip settings as shown on the Drawings. Multi-pole circuit breakers shall have a common operating handle.

2. Provide circuit breakers with interrupting capacity as indicated on plans, minimum interrupting capacity shall be 14,000 symmetrical RMS amperes at 480/277 volts and 10,000-Amps at 208/120 volts.

3. Fusible switches shall be of the quick-made, quick-break, visible blade type and shall be UL listed and horsepower rated. Phase sequence and circuit numbering shall be uniform. Temperature rise and current carrying capacity of busses and parts shall be in accordance with NEMA Standards and NEC requirements. Provide fuses as specified under paragraph, "Fuses", in Section 260500.

4. When indicated, provide circuit breakers and switches with shunt-trips, motor operators or other features as required for the application.

5. Circuit breakers shall be pad-lockable in the "OFF" position. Switches shall be pad-lockable in either the "OPEN" or "CLOSE" position.

D. Identification:

1. Nameplates: Provide nameplates and warning signs as specified, in Section 260553.

2. Provide a nameplate for each circuit breaker or fusible switch with wording to indicate load served.

3. The main nameplate shall give the switchboard designation in 1/2-inch high letters. A second line in 1/4-inch high letters shall indicate the Ampere, Voltage –Phase and Wire. The third line of same dimensions as the second line shall indicate where the equipment fed from.

E. Finish: Supporting framework, cover plates and other metal surface shall first be given a phosphate coating for superior paint adhesion and corrosion resistance. Alkyd amine

standard gray enamel shall be electrostatically applied and baked thoroughly in a convection-type oven to ensure a long lasting, mark resistant finish.

F. Acceptable Manufacturers: Switchboard assembly, switches, circuit breakers, devices and major components shall be of the same manufacturer. Acceptable manufacturers are Square D, General Electric, or Cutler Hammer.

2.6 DISTRIBUTION PANELBOARDS

A. General: Distribution panelboards in general shall comply with the requirements of the distribution switchboards except that distribution panelboards shall be suitable for wall mounting instead of free floor standing.

PART 3 - EXECUTION

3.1 MATERIALS AND WORKMANSHIP

A. General: Material and workmanship shall be as specified in Section 260500.

B. Verify equipment dimensions prior to the installation of the equipment.

3.2 TRENCHING AND BACK FILLING

A. Perform excavation and back fill required for electrical work in accordance with the requirements of Division 2 and the following:

1. Pits and trenches shall be of the minimum size required. Shoring and bracing shall be provided as required to prevent caving of banks.

2. Provide necessary guard rails, barriers, and warning lights. Work shall be scheduled in a manner that excavations shall be open for a minimum period. Back fill shall be in accordance with Division 2.

3. Verify and provide trench back fill per utility companies' requirement where utility runs indicated on Drawings are intended for local utility companies' usage.

4. Where trenches occur in existing areas, restore backfill to match existing conditions.

3.3 INSTALLATION

A. General: The installation of the equipment in this section shall comply with all applicable requirements.

B. Install the equipment in conformance with the manufacturer's installation instructions.

C. Concrete Pull boxes:

1. Install pull boxes in paved areas wherever possible but keep each box a minimum of 1-foot clear of edge of paving. Tops of boxes shall align exactly with top surfaces of paving. In other locations, install boxes where runoff water will not drain to the box and set top of box 2-inch above finished grade of surrounding earth.

2. Except where indicated or where absolutely necessary, make no splices in concrete pull boxes. Where conductors of 600-Volt rating or below must be spliced, use in-line or straight-through type with a heat shrinkable plastic sleeve placed over the splice. Coat the splice thoroughly with Skotchkote Electric Coating.

3. Where different systems share the same pull box, provide transite barriers or other means to provide legal separations. Junction boxes inside concrete pull boxes shall be cast type with threaded hubs and gasketed covers.

4. Immediately below the drain hole in the pull box, install a 12-inch diameter by 4-foot long clay pipe, or concrete pipe, and fill with 1/2-inch size crushed rock.

5. Coat entire below-grade exterior surfaces with an approved waterproofing compound.

6. At end of job, seal the (traffic) cover to the pull box to prevent water entry.

7. Verify and provide per local utility companies' requirements, where pull boxes, manholes and transformer pads indicated on Drawings are intended for local utility companies' usage.

D. Cables: Install cables as indicated and as specified in other sections of these Specifications.

E. Transformers and Voltage Regulators:

1. Transformers shall be floor, wall, or ceiling mounted as indicated.

2. Install all transformers, except small control transformers, on Korfund Series "F" or "H" double-deflection mounts selected for the weight of the transformer to produce the maximum isolation. Provide seismic restraints as indicated and/or required.

3. Install transformers in such a manner that no metal-to-metal, concrete, plaster, or wood contact exists between the transformer and structural members.

4. Mounting bolts in floor-mounted transformers shall extend into pads only and shall not be in direct contact with building structural members.

5. Make conduit connections to transformers with liquid-tight flexible conduit utilizing neoprene gaskets and isolated grounding bushings at the transformer enclosures to achieve complete metal-to-metal sound and vibration isolation.

6. Flexible jumpers shall be installed for grounding continuity from enclosure to conduits or bus ducts.

F. Switchboards (Floor Standing): Foundation channels shall be placed on top of slab, fastened in place, and then filled with grout. Provide additional channel or substantial metal trim to completely enclose the bases across the ends. Channels shall be level to achieve a plumb and true installation. Channels may be poured in the slab. Provide shims as required.

G. Panelboards: Where panel is indicated as recess mounted, provide one 3/4-inch conduit for every three spare breakers (or spaces) stubbed into accessible ceiling space and capped for future use.

H. Motor Controls:

1. Connect "Hand-Off-Auto" selector switches so that automatic control only bypassed in "manual" position and any safety controls are not bypassed.

2. Where indicated and approved by code, motor controllers may be omitted when horsepower-rated thermostat, float or pressure switches, and similar devices are provided which can control the motor directly. Omit motor controls only where motor starting and running protection is established by other means satisfactory to conform with Code requirements.

3. Install motor switches in flush enclosures in finished areas.

4. Examine control diagrams indicated and manufacturer's shop drawings before ordering motor controllers. Controllers shall be ordered to satisfy diagram and Drawing requirements. Should conflicting data exist in Specifications, and diagrams, request corrected data prior to placing orders.

I. Integrated Power Center

1. Installation

a. Install the Integrated Power Center in accordance with manufacturers' written instruction, NEMA Standards Publication PB 2.1 – "Proper Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or Less", and NEC standards.

b. Field Quality Control

c. Inspect complete installation for physical damage, proper alignment, anchorage, and grounding.

d. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads within 20% of each other. Maintain proper phasing for multi-wire branch circuits.

e. Check tightness of bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written specifications.

3.4 TESTS

A. Factory tests shall be conducted prior to shipping of the equipment specified in this Section. Factory tests shall comply with the performance data submitted for approval. Provide certified copies of the reports on all tests, including the complete test data.

B. Field tests shall include testing of the field wiring, circuit to circuit and system to system, to ensure the satisfactory operation of each system complete. Initiate moving parts and door, including locks and latches. All units and components shall operate within the efficiency, repeatability, and accuracy limitations approved and shall in all respects conform to the Drawings, Specifications, and approved submittals.

3.5 GROUNDING

A. General: Install and test grounding as shown on the Drawings and as specified.

3.6 COORDINATION

A. General: As specified in Section 26 05 00.

3.7 QUALITY CONTROL

A. General: As specified in Section 26 05 00.

3.8 INSPECTIONS

A. General: As specified in Section 26 0 500.

END OF SECTION