SECTION 23 05 00
COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS:

A. All drawings associated with the entire project, including general provisions of the Contract, including The General Conditions of the Contract for Construction, General and Supplementary Conditions and Division-1 Conditions specification sections shall apply to the Division 21, 22, and 23 specifications and drawings. The Contractor shall be responsible for reviewing and becoming familiar with the aforementioned and all other Contract Documents associated with the project.

B. Related Sections: Refer to all sections in Division 23. Refer to Division 26 specification sections and Division 26 drawings.

C. Where contradictions occur between this section and Division 1, the more stringent requirement shall apply.

D. Contractor shall be defined as any and all entities involved with the construction of the project.

1.2 SUMMARY:

A. This Section specifies the basic requirements for mechanical installations and includes requirements common to more than one section of Divisions 23. It expands and supplements the requirements specified in Division 1.

1.3 MECHANICAL INSTALLATIONS:

A. The Contract Documents are diagrammatic, showing certain physical relationships which must be established within the mechanical work and its interface with all other work. Such establishment is the exclusive responsibility of the Contractor. Drawings shall not be scaled for the purpose of establishing material quantities.

B. Drawings and specifications are complementary. Whatever is called for in either is binding as though called for in both. Report any discrepancies to the Engineer and obtain written instructions before proceeding. Where any contradictions occur between the specifications and the drawings the more stringent requirement shall apply. The contractor shall include pricing for the more stringent and expensive requirements.

C. Drawings shall not be scaled for rough-in measurements or used as shop drawings. Where drawings are required for these purposes or have to be made from field measurement, Contractor shall take the necessary measurements and prepare the drawings.

D. The exact location for some items in this specification may not be shown on the drawings. The location of such items may be established by the Engineer during the progress of the work.

E. The contract documents indicate required size and points of terminations of pipes, and suggest proper routes to conform to structure, avoid obstructions and preserve clearances. It is not intended that drawings indicate necessary offsets. The contractor shall make the installation in such a manner as to conform to the structure, avoid obstructions, preserve headroom and keep openings and passageways clear, without further instructions or costs to the Owner. All equipment shall be installed so access is maintained for serviceability.
F. Before any work is installed, determine that equipment will properly fit the space; that required piping grades can be maintained and that ductwork can be run as intended without interferences between systems, structural elements or work of other trades.

G. Verify all dimensions by field measurements.

H. Coordinate installation in chases, slots and openings with all other building components to allow for proper mechanical installations.

I. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing-in the building.

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

K. Install mechanical equipment to facilitate maintenance and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

L. Make allowance for expansion and contraction for all building components and piping systems that are subject to such.

M. The ceiling space shall not be “layered”. It is the contractor’s responsibility to offset and system as required to allow installation within the identified ceiling cavity. The contractor shall include labor and material in the base bid to accommodate such offsets.

N. In general, all “static” piping systems shall be routed as high as possible, i.e. fire protection systems. Keep all equipment in accessible areas such as corridors and coordinate with systems and equipment from other sections.

O. The Contractor shall provide all labor and material necessary but not limited to the starting/stopping of all mechanical equipment, opening/closing of all valves, draining/refilling all mechanical systems and operating/verifying the operation of all mechanical systems controls as required to accomplish all work necessary to meet construction document requirements. Contractor shall submit records of such activities to engineer and include in the O & M manuals.

1.4 COORDINATION:

A. Work out all installation conditions in advance of installation. The Contractor shall be responsible for providing all labor and material, including but not limited to all fittings, isolation valves, offsets, hangers, control devices, etc., necessary to overcome congested conditions at no increase in contract sum. The Contractors base bid shall include any and all time and manpower necessary to develop such coordination efforts and drawings. Increases to contract sum or schedule shall not be considered for such effort.

B. Provide proper documentation of equipment, product data and shop drawings to all entities involved in the project.

C. Coordination Drawings:

1. Coordination drawings shall be prepared by the Contractor for his utilization and are his responsibility to assure systems will be installed in a manner to allow all systems to function properly.
1.5 COORDINATION WITH OTHER DIVISIONS:

A. General:

1. Coordinate all work to conform to the progress of the work of other trades.
2. Complete the entire installation as soon as the condition of the building will permit. No extras will be allowed for corrections of ill-timed work, when such corrections are required for proper installation of other work.

1.6 DESIGN WORK REQUIRED BY CONTRACTOR:

A. The construction of this project requires the Contractor to include the detailing and design of several systems and/or subsystems. All such design work associated with the development of the coordination drawings shall be the complete responsibility of the Contractor.

B. The Contractor shall take the full responsibility to develop and complete routing strategies which will allow fully coordinated system to be installed in a fully functional manner. The Engineers contract drawings shall be for system design intent and general configurations.

C. Systems or subsystems which require design responsibility by the contractor include but are not limited to:

1. Any system not fully detailed
2. Equipment supports, hangers, anchors and systems not fully detailed nor specified in these documents, or catalogued by the manufacturer.
3. Temperature controls systems

D. Design Limitations:

1. The Contractor shall not modify the Engineers design intent in any way.
2. The Contractor shall not change any pipe size or equipment size without prior written approval from the Engineer.

1.7 PROJECT CONDITIONS:

A. The Contractor shall make themselves familiar with the existing conditions. No additional costs to the Owner shall be accepted for additional work for existing conditions.

B. Field verify all conditions prior to submitting bids.

C. Report any damaged equipment or systems to the Owner prior to any work.

D. Protect all mechanical and electrical work against theft, injury or damage from all causes until it has been tested and accepted.

E. Be responsible for all damage to the property of the Owner or to the work of other contractors during the construction and guarantee period. Repair or replace any part of the work which may show defect during one year from the final acceptance of all work, provided such defect is, in the opinion of the Architect, due to imperfect material or workmanship and not due to the Owner's carelessness or improper use.

F. The Contractor shall coordinate and co-operate with Owner at all times for all new to existing connections, system shutdowns and start-ups, flushing and filling both new and existing systems.
G. Provide temporary ductwork and piping services, where required, to maintain existing areas operable.

H. Coordinate all services shut-down with the Owner; provide temporary services. Coordinate any required disruptions with Owner, one week in advance.

I. Minimize disruptions to operation of mechanical systems in occupied areas.

1.8 SAFETY:

A. Refer to Division 1.

1.9 EQUAL EMPLOYMENT OPPORTUNITY REQUIREMENTS:

A. Refer to Division 1 and conform with the Owners requirements.

1.10 REQUIREMENTS OF REGULATORY AGENCIES:

A. Refer to Division 1.

B. Execute and inspect all work in accordance with all Underwriters, local and state codes, rules and regulations applicable to the trade affected as a minimum, but if the plans and/or specifications call for requirements that exceed these rules and regulations, the greater requirement shall be followed. Follow recommendations of NFPA, SMACNA, EPA, OSHA and ASHRAE.

C. Comply with the local and state codes adopted by the Authorities Having Jurisdictions at the time of permit application, including referenced standards, amendments and policies. The following are the codes in effect:

1. 2015 International Mechanical Code
2. 2015 International Fuel Gas Code

D. Comply with standards in effect at the date of these Contract Documents, except where a standard or specific date or edition is indicated.

E. The handling, removal and disposal of regulated refrigerants and other materials shall be in accordance with U.S. EPA, state and local regulations.

F. The handling, removal and disposal of lead based paint and other lead containing materials shall comply with EPA, OSHA, and any other Federal, State, or local regulations.

G. After entering into contract, Contractor will be held to complete all work necessary to meet these requirements without additional expense to the Owner.

1.11 PERMITS AND FEES:

A. Refer to Division 1.

B. Contractor shall arrange for and pay for all inspections, licenses and certificates required in connection with the work.
1.12 PRODUCT OPTIONS AND SUBSTITUTIONS:

A. Refer to the Instructions to Bidders and Division 1.

B. The burden of proof that proposed equipment is equal in size, capacity, performance, and other pertinent criteria for this specific installation, or superior to that specified is up to the Contractor. Substituted equipment will only be allowed where specifically listed in a written addendum. If substitutions are not granted, the specified materials and equipment must be installed. Where substituted equipment is allowed, it shall be the Contractor’s responsibility to inform all related trades of the accepted substitution and to assume full responsibility for all costs caused as a result of the substitution.

C. Materials and equipment of equivalent quality may be submitted for substituted prior to bidding. This may be done by submitting to the /Engineer at least ten (10) working days prior to the bid date requesting prior review. This submittal shall include all data necessary for complete evaluation of the product.

1. Substitutions shall be allowed only upon the written approval of the /Engineer NO EXCEPTIONS.
2. The Contractor shall be responsible for removal, replacement and remedy of any system or equipment which has been installed which does not meet the specifications or which does not have prior approval.

1.13 MECHANICAL SUBMITTALS:

A. General

1. Refer to the Conditions of the Contract (General and Supplementary), Division 1.
2. Contractor shall provide a submittal schedule appropriate for the size and schedule of the project. Limit the number of large submittals being reviewed at one time and coordinate timing of sections that are dependent on each other.
3. The Contractor shall identify any "long lead time" items which may impact the overall project schedule. If these submittal requirements affect the schedule, the Contractor shall identify the impacts and confer with the Engineer within two weeks of entering into the contract.
4. The front of each submittal package shall be identified with the specification section number, job name, Owner's project number, date, Prime Contractor and Sub-Contractor's names, addresses, and contact information, etc. Each Specification Section shall be submitted individually and submittal shall be tabbed for the equipment/materials/etc. within the section. Submittals that are not complete with the required information will not be reviewed and will be sent back to be corrected.
5. Submittals shall be provided electronically. All electronic submittals need to be complete with all design information and stamped for conformity by the contractor. Submittals will be reviewed, marked appropriately and returned by the same means received.
6. An index shall be provided which includes:
   a. Product
   b. Plan Code (if applicable)
   c. Specification Section
   d. Manufacturer and Model Number
7. Submittal schedule shall be provided for review within four (4) working weeks from award of contract to successful bidder.

B. Basis of Design: The manufacturer's material or equipment listed in the schedule or identified by name on the drawings are the basis of design and provided for the establishment of size, capacity,
grade and quality. If alternates are used in lieu of the scheduled names, the cost of any changes in construction required by their use shall be borne by Contractor.

C. All equipment shall conform to the State and/or local Energy Conservation Standards.

D. Contractor Review: Submittal of shop drawings, product data and samples will be accepted only when submitted by and stamped by the General Contractor. Each submittal shall be reviewed by the contractor for general conformance with contract requirements and stamped by the respective contractor prior to submittal to the Architect/Engineer. Any submittal not stamped or complete will be sent back. Data submitted from Subcontractors and material suppliers directly to the Engineer will not be processed unless prior written approval is obtained by the Contractor.

E. Submittal Review Process: Before starting work, prepare and submit to the Engineer shop drawings and descriptive equipment data required for the project. Continue to submit in the stated format after each Engineer's action until a "No Exception Taken" or "Make Correction Noted" action is received. When a "Make Corrections Noted" is received, make the required corrections for inclusion in the Operating and Maintenance Manual (O&M). Submittals marked "Make Corrections Noted" shall not be resubmitted during the submittal process. Unless each item is identified with specification section and sufficient data to identify its compliance with the specifications and drawings, the item will be returned "Revise and Resubmit". Where an entire submittal package is returned for action by the Contractor, the Engineer may summarize comments in letter format and return the entire set. Submittals shall be prepared per the MECHANICAL SUBMITTAL CHECKLIST, at the end of this section; supplemental requirements are listed in each Division 21, 22, and 23 Sections.

F. The Design Professional's review and appropriate action on all submittals and shop drawings is only for the limited purpose of checking for conformance with the design concept and the information expressed in the contract documents. This review shall not include:

1. Accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes
2. Construction means or methods
3. Coordination of the work with other trades
4. Construction safety precautions

G. The Design Professional's review shall be conducted with reasonable promptness while allowing sufficient time in the Design Professional's judgment to permit adequate review. Review of a specific item shall not indicate that the Design Professional has reviewed the entire assembly of which the item is a component.

H. The Design Professional shall not be responsible for any deviations from the contract documents not brought specifically to the attention of the Design Professional in writing by the Contractor. This shall clearly identify the design and the specific element which vary from the Design. The Contractor shall be responsible for all remedy for lack of strict conformance associated with this criteria.

I. The Design Professional shall not be required to review partial submissions or those for which submissions of correlated items have not been received.

J. If more than two submittals (either for product data, shop drawings, record drawings, or test and balance reports) are made by the Contractor, the Owner reserves the right to charge the Contractor for subsequent reviews by their consultants. Such extra fees shall be deducted from payments by the Owner to the Contractor.

K. The contractor shall cloud all changes made on submittals that are marked “Revise and Resubmit.”
L. Required Submittals: Provide submittals for each item of equipment specified or scheduled in the contract documents. See table at the end of this section.

1.14 SPECIFIC CATEGORY SUBMITTAL REQUIREMENTS:

A. Product Listing:
   
   1. Unless otherwise specified, all materials and equipment shall be of domestic (USA) manufacture and shall be of the best quality used for the purpose in commercial practice.
   
   2. When two or more items of same material or equipment are required (plumbing fixtures, pumps, valves, air conditioning units, etc.) they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units and similar items used in work, except as otherwise indicated.

   a. Provide products which are compatible within systems and other connected items.

B. Product Data:
   
   1. Where pre-printed data covers more than one distinct product, size, type, material, trim, accessory group or other variation, mark submitted copy with black pen to indicate which of the variations is to be provided.
   
   2. Delete or mark-out portions of pre-printed data which are not applicable.
   
   3. Where operating ranges are shown, mark data to show portion of range required for project application.
   
   4. For each product, include the following:

   a. Sizes.
   b. Weights.
   c. Speeds.
   d. Capacities.
   e. Piping and electrical connection sizes and locations.
   f. Statements of compliance with the required standards and regulations.
   g. Performance data.
   h. Manufacturer's specifications.

C. Coordination Drawings: See separate paragraph of this specification section.

D. Test Reports:
   
   1. Submit test reports which have been signed and dated by the accredited firm or testing agency performing the test.
   
   2. Prepare test reports in the manner specified in the standard or regulation governing the test procedure (if any) as indicated.
   
   3. Submit test reports as required for O & M manuals.

E. Operation and Maintenance Data: See separate paragraph of this specification section.

F. Software Licenses: Provide documentation of ownership under the owner’s corporate name (coordinate with owner’s representative for exact ownership wording) for Software Licenses provided as part of the work. Include information for updates, subscription requirements if applicable, backup, support, login, passwords, date when purchased, expiration date if applicable, version, etc. Include in the O & M Manual after review and "No Exceptions Taken" has been accomplished.
G. Record Drawings: See separate paragraph of this specification section.

1.15 DELIVERY, STORAGE, AND HANDLING:

A. Refer to Division 1 Sections on Transportation and Handling and Storage and Protection.

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

C. Check delivered equipment against contract documents and submittals.

D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage, dirt, dust, freezing, heat and moisture.

E. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

F. Provide factory-applied plastic end-caps on each length of pipe and tube, except for concrete, corrugated metal, hub-and-sbigot, clay pipe. Maintain end-caps through shipping, storage and handling to prevent pipe-end damage and prevent entrance of dirt, debris and moisture.

G. Protect stored ductwork, pipes and tubes. Elevate above grade and enclose with durable, waterproof wrapping. When stored inside, do not exceed structural capacity of the floor.

H. Protect flanges, fittings and specialties from moisture and dirt by inside storage and enclosure, or be packaging with durable, waterproof wrapping.

I. Protect sheet metal ductwork and fittings. Elevate and store above grade and cover ends with waterproof wrapping.

1.16 DEMOLITION:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. During the demolition phase of this contract it is the responsibility of this Contractor to carefully remove existing equipment, piping or ductwork and related items either as shown on the demolition drawings as being removed, or as required for the work. These items shall be tagged, protected from damage and stored as directed by the Owner. A list of all items stored shall be turned over to the Engineer. At the completion of the remodeling work or when directed, all stored items not re-used or wanted by the Owner shall be removed from the premises.

C. The location of existing equipment, pipes, ductwork, etc., shown on the drawings has been taken from existing drawings and is, therefore, only as accurate as that information. All existing conditions shall be verified from field measurements with necessary adjustment being made to the drawing information.

D. Hazardous Material: If suspected hazardous material, in any form, is discovered by this Contractor in the process of his work, he shall report such occurrence to the Owner immediately. The Owner will determine the action to be taken for the hazardous material removal, which is not a part of the work to be done under this Division.
1.17 CUTTING AND PATCHING:

A. This Article specifies the cutting and patching of mechanical equipment, components and materials to include removal and legal disposal of selected materials, components and equipment. Coordinate the cutting and patching of building components to accommodate the installation of mechanical equipment and materials.

B. Refer to Division 1.

C. Do not endanger or damage installed work through procedures and processes of cutting and patching.

D. Arrange for repairs required to restore other work, because of damage caused as a result of mechanical installations.

E. No additional compensation will be authorized for cutting and patching work that is necessitated by ill-timed, defective or non-conforming installations.

F. Perform cutting, fitting and patching of mechanical equipment and materials required to:
   1. Uncover work to provide for installation of ill-timed work;
   2. Remove and replace defective work;
   3. Remove and replace work not conforming to requirements of the Contract Documents;
   4. Remove samples of installed work as specified for testing;
   5. Install equipment and materials in existing structures;
   6. Upon written instructions from the Architect/Engineer, uncover and restore work to provide for Engineer observation of concealed work.

G. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including, but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim and other mechanical items made obsolete by the new work.

H. Protect the structure, furnishings, finishes and adjacent materials not indicated or scheduled to be removed.

1.18 ACCESSIBILITY:

A. Install equipment and materials to provide required access for servicing and maintenance. Coordinate the final location of concealed equipment and devices requiring access with final location of required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

B. Final installed conditions shall accommodate accessibility and replacement of system components that regularly require service and replacement. This includes control devices, sensors, motors, etc. Such devices shall not be permanently obstructed by building systems such as piping, ductwork, insulation, drywall, etc.

1.19 NAMEPLATE DATA:

A. Provide permanent operational data nameplate, refer to the section on Mechanical Identification, on each item of mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location. Coordinate with Owner for specific requirements.
1.20 LUBRICATION OF EQUIPMENT:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Contractor shall properly lubricate all mechanical pieces of equipment which he provided before turning the building over to the Owner. He shall attach a linen tag or heavy duty shipping tag on the piece of equipment showing the date of lubrication and the type and brand of lubricant used.

C. Furnish the Engineer with a typewritten list included in the O&M manuals of each item lubricated and type of lubricant used, no later than two (2) weeks before completion of the project, or at time of acceptance by the Owner of a portion of the building and the mechanical systems involved.

1.21 CLEANING:

A. Refer to Division 1.

1.22 RECORD DOCUMENTS:

A. Refer to Division 1. The following paragraphs supplement the requirements of Division 1.

B. Keep a complete set of record document prints in custody during entire period of construction at the construction site. Documents shall be updated on a weekly basis.

C. Mark Drawing Prints to indicate revisions to piping and ductwork, size and location both exterior and interior; including locations of coils, dampers and other control devices, filters, boxes, and similar units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned to column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices. Changes to be noted on the drawings shall include final location of any piping or ductwork relocated more than 1 foot-0 inches from where shown on the drawings.

D. Mark shop drawings to indicate approved substitutions; Change Orders; actual equipment and materials used.

E. Mark equipment and fixture schedules on drawings to indicate manufacturer and model numbers of installed equipment and fixtures.

F. Revisions to the Contract Documents shall be legible and shall be prepared using the following color scheme:

1. Red shall indicate new items, deviations and routing.
2. Green shall indicate items removed or deleted.
3. Blue shall be used for relevant notes and descriptions.

G. At the completion of the project, obtain from the Architect a complete set of the Mechanical Contract Documents in a read-only electronic format (.pdf unless otherwise noted). This set will include all revisions officially documented through the Architect/Engineer. Using the above color scheme, transfer any undocumented revisions from the construction site record drawings to this complete set. Submit completed documents to the Architect/Engineer. This contract will not be considered completed until these record documents have been received and reviewed by the Architect/Engineer.
H. Contractor may propose methods of maintaining record documents on electronic media. Obtain approval of Engineer and Owner prior to proceeding. Marked-up .pdf format readable by Bluebeam is preferred.

1.23 OPERATION AND MAINTENANCE DATA:

A. No later than four (4) weeks prior to the completion of the project provide one complete set of Operating and Maintenance Manuals, or as specified in Sections of Division 1 (whichever is more stringent).

B. The testing and balancing report shall be submitted and received by the Engineer at least fifteen calendar days prior to the contractor's request for final observation time frame requirements. Include in the O & M Manual after review with "No Exceptions Taken" has been accomplished.

C. In addition to the information required by Division 1 for Maintenance Data, include the following information:

1. The job name and address and contractor's name and address shall be identified at the front of the electronic submittal.
2. Description of mechanical equipment, function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of all replaceable parts.
3. Manufacturer's printed operating procedures to include start-up, break-in, routine and normal operating instructions; regulation, control, stopping, shut-down, and emergency instructions; and summer and winter operating instructions. Provide any test reports and start-up documents.
4. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
5. Servicing instructions, lubrication charts and schedules, including Contractor lubrication reports.
6. Manufacturer's service manuals for all mechanical equipment provided under this contract.
7. Name, Address and Telephone numbers of the Sub-contractors and local company and party to be contacted for 24-hour service and maintenance for each item of equipment.
8. Starting, stopping, lubrication, equipment identification numbers and adjustment clearly indicated for each piece of equipment.
9. Complete recommended spare parts list.
10. Mechanical System and Equipment Warranties.
11. Copies of all test reports shall be included in the manuals.
12. Provide manuals with dividers for major sections and special equipment. Mark the individual equipment when more than one model or make is listed on a page. Provide detailed table of contents.
13. Contractor may propose methods of maintaining record documents on electronic media. Obtain approval of Engineer and Owner prior to proceeding. Marked-up PDF format readable by Bluebeam is preferred.

D. This contract will not be considered completed nor will final payment be made until all specified material, including test reports, and final Schedule of Values with all Electrical and Information Technology change order costs included and identified is provided and the manual is reviewed by the Architect/Engineer.

1.24 PROJECT CLOSEOUT LIST:

A. In addition to the requirements specified in Division 1, complete the requirements listed below.
B. The Contractor shall be responsible for the following Mechanical Submittal Checklist either by performing and/or coordinating such items prior to applying for certification of substantial completion. Refer to individual specification sections for additional requirements. (Checklist is located at the end of this section.)

1.25 WARRANTIES:

A. Refer to the Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements. In any case the entire mechanical system shall be warranted no less than one year from the time of acceptance by the Owner.

B. Compile and assemble the warranties specified in Division 21, 22, and 23 in the Operating and Maintenance Manuals.

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

1.26 CONSTRUCTION REQUIREMENTS:

A. The contractor shall maintain and have available at the jobsite current information on the following at all times:

1. Up to date record drawings.
2. Submittals
3. Site observation reports with current status of all action items.
4. Test results; including recorded values, procedures, and other findings.
5. Outage information.

1.27 EQUIPMENT HOUSEKEEPING PADS:

A. Provide 4" concrete housekeeping pad for all floor mounted equipment including, but not limited to: air compressors, air handling units, boilers, chillers, condensing units, cooling towers, deaerators, fans, furnaces, medical gas equipment, processed water systems pumps, storage tanks, water heaters, and water treatment systems. Fabricate pads as follows:

1. Coordinate size of equipment bases with actual unit sizes provided. Fabricate base 4" larger in both directions than the overall dimensions of the supported unit.
2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad.
3. Place concrete and allow to cure before installation of units. Use Portland cement that conforms to ASTM C 150, 4000-psi compressive strength, and normal weight aggregate.
4. Anchor housekeeping pads to slab using #3 rebar bent in “L” or “Z” shape 12 inch on center on each side of slab.
### 1.28 MECHANICAL SUBMITTAL CHECKLIST:

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Notes:

1. For Starters and Variable Frequency Drives
2. Requires Review & Approval of calibrated balance valves from T & B Contractor
3. See Specific Specification Section for Test & Certification Requirements

END OF SECTION 23 05 00
SECTION 23 05 07
MOTOR, DRIVES, MOTOR CONTROLLERS AND ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies the basic requirements for electrical components which are either separate components or are an integral part of all mechanical equipment. These components include, but are not limited to starters, variable frequency drives and disconnect switches.

B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.

C. Refer to electrical drawings and specifications for specific electrical requirements pertaining to mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by Contractor. Provide equipment that meets all of the electrical requirements including but not limited to:

1. Voltage and number of phases
2. Circuit Ampacity,
3. Maximum Overcurrent protection
5. Wire size listed. Provide lugs with the ability to terminate the provided wire size at each piece of equipment.

As a minimum provide nameplate with the above information for each piece of equipment.

D. SCCR at incoming terminals and throughout the equipment shall be rated for the available fault current at the equipment as indicated and/or required. In addition to meeting NEC requirements, including 450.52 and 450.53, provide one of the following two options based on the equipment configuration:

1. Provide individual fused disconnects rated for the available short circuit current at the disconnect with current limiting fuses supplying mechanical equipment and packaged equipment (for example; a single piece of equipment or starter, a packaged piece of equipment such as a rooftop unit, etc.). See Division 26 requirements for disconnects, fuses, available short circuit values, etc. SCCR of the equipment can be rated for the let thru of the fuse WHEN the equipment does not have a main or other circuit breaker that provides additional levels of branch circuit/short circuit protection AND if acceptable to the authority having jurisdiction.

2. Provide fully rated devices with the appropriate interrupting rating above the available fault current levels for circuits feeding equipment that contain an overcurrent device such as a main or other circuit breakers that provide additional levels of branch circuit or short circuit protection (for example: circuit breakers provided for multiple motors, VFD’s, etc. The nameplate on this type of equipment shall indicate an SCCR above the available fault level at the equipment.

3. Equipment protection schemes shall be submitted with equipment cutsheets/shop drawings.

E. Refer to Table in Division 1 for Mechanical/Electrical coordination.

F. See other sections of Division 23 for vibration and seismic control requirements.
1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Single Manufacturer: Provide all motors, starters and VFDs for the project by a single manufacturer except when part of factory packaged equipment. All variable frequency drives and starters for the project shall be by a single manufacturer, including packaged equipment, except chillers, etc.

C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motors, motor starters, capacitors and drives similar to that required for this project.

D. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors and drives.

E. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces".

F. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.

G. UL Compliance: Provide equipment and components which are UL-listed and labeled.

H. ETL Compliance: Provide equipment and components which are ETL-listed and labeled.

I. IEEE Compliance: Comply with applicable requirements of IEEE including Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters and Std 519.

J. NEMA Compliance: Comply with applicable requirements of NEMA including Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies", and Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)", pertaining to motor controllers/starters and enclosures.

K. In addition comply with the following standards:
   1. NEMA Standards MG 1: Motors and Generators.
   2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.

L. Comply with National Electrical Code (NFPA 70).

M. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 26 sections. Comply with applicable requirements of Division 26 sections for electrical work of this section which are not otherwise specified.

1.3 SUBMITTALS:

A. Product Data: Submit in accordance with Section 23 05 00 “Common Work Results for Mechanical”.

B. Shop Drawings: Submit dimensional drawings of VFD’s and starters showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general
arrangements with incoming and outgoing conduit locations, schematic; connection diagram sufficient to install system, and enclosure details.

C. Wiring Diagrams: Submit schematic power and control wiring diagrams, prepared for this project, of complete VFD and starter assemblies. General wiring diagrams with various non-applicable options shown are not acceptable. Clearly differentiate between factory and field wiring.

D. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.

1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with equipment containing motor or separately from equipment.

E. Electrical coordination listing. Provide the following information for each field wired electrical power connection. Information shall use nameplate data and nomenclature of actual installed nameplates. Information should list as a minimum:

1. Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase.
2. Number and location of field connections.
3. Field interconnection wiring.
4. Nameplate Information, as a minimum include:
   a. Operating voltage and phase.
   b. Maximum fuse size (MFS) or maximum overcurrent protection size (MOP) (as applies).
   c. Minimum circuit ampacity (MCA).
   d. Full load amperes (FLA).
   e. Short Circuit Current Rating (SCCR).
5. Locked rotor current (LRA) and duration for high inertia equipment.
6. Manufacturers recommended overload setting (if applicable).

F. The contractor shall fully coordinate these items with all subcontractors prior to submittal.

G. Equipment provided shall match electrical equipment and protection/distribution sizes and be rated for available short circuit currents as shown on the drawings.

1.4 PRODUCT STORAGE:

A. All variable frequency drives, starters, etc. shall be protected from dirt, debris, and moisture at all times. Variable frequency drives shall be wrapped air and water tight with dust-tight and moisture proof material until factory start-up of variable frequency drives is initiated.

1. Exception: Drives may be opened only during wiring terminations by temperature control contractor and/or electrical contractors.

B. All motors not designed for exposure to water or moisture shall be protected at all times.
PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:

1. Variable Frequency Drives
   a. ABB
   b. Allen-Bradley
   c. Square D
   d. Toshiba
   e. Siemens
   f. Yaskawa

2.2 DISCONNECT SWITCHES:

A. See Division 26 for electrical requirements, coordinate disconnect switch selection, installation, and wiring for equipment being provided.

2.3 VARIABLE FREQUENCY DRIVES:

A. General:

1. Comply with NEMA (including NEMA ICS 7.1), and IEEE (including IEEE 519) Standards as applicable to wiring methods, construction and installation and operation of VFDs. Comply with applicable requirements of UL 908. “Power Conversion Equipment” and UL 508. Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing. The entire unit shall carry this label, not just components.

2. Provide the following factory tests on VFD assembly as a complete package (not just individual components):

   a. High pot test per UL 508.
   b. Test assembled panel with a motor load.
   c. Test operation of all components and pilot lights.

3. The manufacturer shall verify compatibility of each VFD unit with the motor being supplied under Division 23. The vendor shall be responsible for reviewing Division 23 specifications sections, plans and schedules related to motors prior to bid and shall notify the Engineer at least ten (10) days prior to the bid of any discrepancies or incompatibilities between VFD units and motor characteristics.

B. Enclosure and support:

1. Provide NEMA enclosure suitable for the environment in which the VFD is to be installed. Provide floor stand where building walls are not suitable for mounting drive.

2. Where installed within an enclosure, the enclosure shall be provided with filtered, thermostatically controlled fan powered ventilation, and a thermostatically controlled heater. Fan shall be sized for “dirty filter” condition, at project altitude.

3. Drive and by-pass enclosure doors shall have provisions for locking with a padlock or integral lock, keyed to the building standards.

4. Switches and pilot lights shall be labeled with engraved plastic laminate tags riveted or similarly permanently fastened.
C. Input Power:

1. The drive shall be capable of accepting facility power as specified on the drawings. Variations of up to plus or minus 10 percent of line voltage and plus or minus 2Hz of line frequency shall be permitted without the drive shutting down on a fault.
2. Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault.
3. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.
4. The drive efficiency at rated load and frequency shall be 95 percent or better.
5. The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load.
6. Manufacturer shall guarantee that harmonic voltage and current distortion, on the line side (input terminals) of the VFD does not exceed 5 percent total voltage Harmonic distortion, and 15 percent total current Harmonic distortion.
   a. Manufacturer shall correct harmonic voltage and current distortion with an AC line reactor, an isolation transformer, or a tuned filter to stay within the above limit.
   b. Manufacturer shall review electrical drawings to determine optimum characteristics of the reactor/filter system.
   c. The installed drive shall be tested to verify the above distortion limits. The manufacturer shall replace the reactor/filter system if the installed drive does not meet the THD criteria. See Part 3.

D. Output Power:

1. The variable frequency AC drive shall convert 3 phase, 60 Hz input power to an adjustable AC frequency and voltage for controlling the speed of any standard NEMA B Design, AC squirrel cage motors driving variable torque loads. The drive shall be rated for continuous duty at the NEC standard full load current of its associated motor.
2. Transistors (IGBT) to produce a sine weighted PWM three phase output for the load.
3. The drive shall have sufficient capacity to provide stepless speed control of the motor throughout the operating range as specified herein.
4. The drive output will be adjustable from 0 to 60 Hz.
5. The drive shall have the capability to adjust the frequency above 4 kHz. The drive shall not operate with a frequency above 12 kHz.
6. The IGBTs shall have a minimum rating of 1200 VDC on 480 V units and 600 VDC on 230 V units.
7. The drive shall be suitable for operating at the altitude of the project location with no degradation or loss of performance.

E. Control and Operation Features:

1. Adjustable acceleration and deceleration, with automatic acceleration rate limiting to avoid overload and automatic deceleration rate limiting to avoid excessive regeneration voltage.
2. Speed/frequency settings to limit the maximum and minimum motor speed, to avoid up to 3 system critical resonance points and to provide a preset speed for operation in the event of loss of the remote speed signal.
3. Capability to set drive to a pre-determined speed upon a contact closure input from the BAS.
4. Capability of restarting into a rotating motor.
5. The following operator control and monitoring functions shall be accessible without opening the door of the enclosure.
   a. HAND/OFF/AUTO (or Local/Off/Remote) selector switch.
1) With the “H-O-A” switch in the “HAND” or “LOCAL” position, the motor shall start in either VFD or by-pass mode as determined by VFD/OFF/BYPASS switch, and if in the “VFD” mode, the speed shall be controlled by the manual speed adjustment on the drive door.

2) With the “H-O-A” switch in “AUTOMATIC” or “REMOTE”, the motor shall start from the remote start/stop input in either VFD or by-pass mode as determined by the VFD/OFF/BYPASS switch and, if in the “VFD” mode, its speed shall be controlled by the BAS input speed signal.

3) With the “H-O-A” switch in the “OFF” position, the run circuit will be open and the VSC will not operate.

4) This must be a physical switch, not a keypad input function.

b. Manual (local) speed adjustment.

c. Frequency (speed) indication.

d. Output amperage indication.

e. Pilot lights for:

1) Power On (green)
2) VFD Fault (red)
3) External Fault (red)
4) Motor on VFD (green)
5) Motor Overload (red)

6. The following control interfaces shall be provided:

a. Remote start/stop (run enable input)

1) Provide a control relay and a terminal block in the by-pass compartment to allow remote start/stop in either the VFD or by-pass mode.

b. Remote speed input signal

1) 4-20 mA, 0-5 VDC, 0-10 VDC, or as required by control system. Coordinate with Section 23 09 33.

c. Safeties interlock input

1) Provide a control relay and terminal block in the by-pass compartment to allow hardwired safety shutdown in either the VFD or by-pass mode.

d. Fault indication output contacts. Indicate fault for the following:

1) Drive protection features
2) Safety interlock
3) Drive hardware fault
4) Input power fault
5) Others as provided by manufacturer

e. Speed indication output (isolated)

f. Amperage indication output.

g. Run forward input.

h. Run backward input.

i. Drive running (status) output.

j. Drive on by-pass output.

k. Drive on manual output.
l. Pre-set speed input.
m. RS 485 communications to DDC system.
n. Complete open protocol communications with DDC system.

7. Provide a key pad and scrolling LCD display for operator interface with programming capabilities, fault diagnostics, fault reset, and security lockout code. Information shall be presented in plain English, not requiring codes.

8. In addition to the interlock and switches specified above, each variable frequency drive shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open and (2) two normally closed.

F. Drive protection and safety features:

1. Provide equipment with Short Circuit Current Rating (SCCR) above available fault current.
2. Electronic motor overload protection including thermal modeling type thermal protection, Ground fault protection, individual monitoring of motor current in each phase, and a wide FLA adjustment and selectable trip.
3. Over-voltage/under-voltage protection.
   a. The VFD shall be arranged to provide the option for automatic restart after a trip condition resulting from over-voltage or under-voltage.
   b. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts.
   c. Settings shall be 110% for overvoltage and 80-90% for under voltage unless stated otherwise on the motor data sheets.

4. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
5. Input phase loss.
   a. The VFD shall be arranged to provide the option for automatic restart after a trip condition resulting from loss of phase.
   b. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts.

6. Voltage and current unbalance. Settings shall be 10-15% of FLA for current unbalance alarm with 5-10 second delay and 20-25% of FLA for current unbalance trip with 2-5 second delay unless otherwise stated on the motor data sheets.
7. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
8. High/over temperature protection.
9. VFD shall include a “Bus Charged” warning indicator, and shall be provided with automatic circuitry to discharge the bus within 120 seconds after main power is disconnected.

G. Each drive shall include connector to allow downloading of parameter settings and fault history logs to a standard computer. Software to allow download of setting shall be included.

2.4 EQUIPMENT FABRICATION:

A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.
PART 3 - EXECUTION

3.1 INSTALLATION:

A. Deliver starters, VFDs and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.

B. Install power and control connections for motors to comply with NEC and applicable provisions of Division 26 sections. Install grounding except where non-grounded isolation of motor is indicated.

C. Where a separate disconnect switch is provided in the motor feeders between a VFD and the motor, provide end switch/auxiliary contacts at the disconnect and interconnect to the VFD to open the remote interlock shutdown (safety)circuit (De-energizes power to the VFD).

3.2 VFD START-UP SERVICES:

A. Provide field start-up service by an authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up services shall include system check-out, start-up and system run.

B. Start-up adjustments shall include optimizing frequency, optimizing volts/Hz ratio, identifying and avoiding resonant speeds, setting accel/decel ramps, and setting overload and circuit breaker trip points.

3.3 INSTALLATION COORDINATION:

A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.

B. Verify windings of multi-speed or reduced voltage starters are compatible with the connected motor prior to installation.

C. All control wiring to be in accordance with manufacturer's recommendations; all wiring shall be color coded to facilitate checking.

D. It is the intent of this specification that one "General" Contractor enters an agreement with the Owner. The use and coordination of subcontractors is at the option of the General Contractor. All mechanical equipment, motors and controls shall be furnished, set in place, and wired. The schedule contained in Division 1 / 26 is provided as a guide only. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of the schedule is to have the Division 23 and 26 Contractors responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 26 for all electrical work which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Contractor shall refer to the Division 26 and Division 23 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

END OF SECTION 23 05 07
PART 1 - GENERAL

1.1 SUBMITTALS:

A. Refer to Division 1 and Section 23 05 00 “Common Work Results for Mechanical” for administrative and procedural requirements for submittals.

B. Product Data: Submit industry standards and manufacturer's technical product data, installation instructions, and dimensioned drawings for each type of pipe and pipe fitting. Submit piping schedule showing pipe or tube weight, fitting type, and joint type for each piping system.

C. Welding Certifications: Submit reports as required for piping work.

D. Brazing Certifications: Submit reports as required for piping work.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of pipes and pipe fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Welder's Qualifications: All welders shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX, Welding and Brazing Qualifications.

C. Welding procedures and testing shall comply with the latest revisions of the applicable sections for B31, of the ANSI/ASME standard codes for pressure piping, noted as follows: B31.1 - Pressure Piping Code / B31.2 - Fuel Gas Piping Code / B31.5 - Refrigeration Piping / B31.9 - Building Service Piping Code.

D. Before any welding is performed, the contractor shall submit to the Architect/Engineer, or his authorized, a copy of the Manufacturer's Record of Welder or Welding Operator Qualification Tests and his Welding Procedure Specification together with the Procedure Qualification Record as required by ASME Boiler and Pressure Vessel Code.

E. Each manufacturer or contractor shall be responsible for the quality of welding done by his organization and shall repair or replace any work not in accordance with these specifications.

F. Soldering and Brazing procedures shall conform to ANSI Standard Safety Code for Mechanical Refrigeration.

PART 2 - PRODUCTS

2.1 GENERAL:

A. Piping Materials: Provide pipe and tube of type, pressure and temperature ratings, capacities, joint type, grade, size and weight (wall thickness or Class) indicated for each service. Where type, grade or class is not indicated, provide proper selection as determined by Installer for installation requirements, and comply with governing regulations and industry standards.

B. Pipe/Tube Fittings: Provide factory-fabricated fittings of type, materials, grade, class and pressure rating indicated for each service and pipe size. Provide sizes and types matching pipe, tube, valve or
equipment connection in each case. Where not otherwise indicated, comply with governing regulations and industry standards for selections, and with pipe manufacturer's recommendations where applicable.

2.2 STEELPIPES AND PIPE FITTINGS:

A. Black Steel Pipe: ASTM A 53, Grade B, type E, electric resistance welded.

B. Seamless Steel Pipe: ASTM A 53, Grade B, type S or A106 high temperature.

C. Cast-Iron Flanged Fittings: ANSI/ASME B16.1, including bolting (Class 125 and 250).


E. Malleable-Iron Threaded Fittings: ANSI/ASME B16.3; plain or galvanized as indicated (Class 125 and 300).

F. Malleable-Iron Threaded Unions: ANSI B16.39, Class 150, 250 or 300; selected by Installer for proper piping fabrication and service requirements, including style, end connections, and metal-to-metal seats (iron, bronze or brass); plain or galvanized as indicated (Class 150, 250 and 300).


H. Steel Flanges/Fittings: ANSI/ASME B16.5, ASTM A234 (Fire Protection) including bolting and gasketing of the following material group, end connection and facing, except as otherwise indicated.
   - Material Group: Group 1.1.
   - End Connections: Buttwelding.
   - Facings: Raised-face.

I. Steel Pipe Flanges for Waterworks Service: AWWA C207 (water service piping only).

J. Forged-Steel Socket-Welding and Threaded Fittings: ANSI B16.11, except MSS SP-79 for threaded reducer inserts; rated to match schedule of connected pipe (up to 4 inch pipe size).

K. Wrought-Steel Buttwelding Fittings: ANSI B16.9, except ANSI B16.28 for short-radius elbows and returns; rated to match connected pipe.

L. Forged Branch-Connection Fittings: Except as otherwise indicated, provide type as determined by Installer to comply with installation requirements.

M. Pipe Nipples: Fabricated from same pipe as used for connected pipe; except do not use less than Schedule 80 pipe where length remaining unthreaded is less than 1-1/2 inches, and where pipe size is less than 1-1/2 inches, and do not thread nipples full length (no close-nipples).

2.3 MISCELLANEOUS PIPING MATERIALS/PRODUCTS:

A. Welding Materials: Except as otherwise indicated, provide welding materials as determined by Installer to comply with installation requirements.
B. Soldering Materials: All soldering materials shall be lead free.
   1. 95-5 Tin-Antimony: ASTM B 32, Grade 95TA. Melting Range 450-470 degrees F.
   3. Flux: All flux shall be lead free, water soluble, and compatible with the solder and the materials being joined. ASTM B813-93.

C. Brazing Materials: Except as otherwise indicated, provide brazing materials to comply with installation requirements.
   1. Comply with AWSA 5.8, Section II, ASME Boiler and Pressure Vessel Code for brazing filler metal materials.
      a. Copper phosphorus -Bcup-5, 15 percent solver content, melting range 1190 to 1480 degrees F.
      b. Silver - BAg-36, 45 percent silver, cadmium-free. Melting range 1195 to 1265 degrees F.

D. Gaskets for Flanged Joints: ANSI B16.21; full-faced for cast-iron flanges; raised-face for steel flanges, unless otherwise indicated.

E. Pipe Thread Sealant Material: Except as otherwise indicated, provide all pipe threads with the sealant material as recommended by the manufacturer for the service.
   1. Manufacturer: Subject to compliance with requirements, provide piping thread sealant material of the following:
      a. The Rectorseal Corporation

PART 3 - EXECUTION

3.1 EXAMINATION:
A. Verify all dimensions by field measurements. Verify that all water distribution piping may be installed in accordance with pertinent codes and regulations, and original design, and the referenced standards.
B. Examine rough-in requirements for plumbing fixtures and other equipment having water connections to verify actual locations of piping connections prior to installation.
C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PIPING INSTALLATION:
A. General: Install pipes and pipe fittings in accordance with recognized industry practices which will achieve permanently-leakproof piping systems, capable of performing each indicated service without piping failure. Install each run with minimum joints and couplings, but with adequate and accessible unions for disassembly and maintenance/replacement of valves and equipment. Reduce sizes (where indicated) by use of reducing fittings. Align piping accurately at connections, within 1/16 inch misalignment tolerance.
   1. Comply with ANSI B31 Code for Pressure Piping.
   2. Electrical Equipment Spaces: Do not run piping through transformer vaults and other electrical or electronic equipment spaces and enclosures. Only piping serving this type of equipment space shall be allowed.
3. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Locations and arrangements of piping take into consideration pipe sizing and friction loss, expansion, pump sizing, and other design considerations. So far as practical, install piping as indicated.

4. Use fittings for all changes in direction and all branch connections.

5. Install piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

6. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

7. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

8. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

9. Install drains in pressure pipe systems at all low points in mains, risers, and branch lines consisting of a tee fitting, ¾ inch ball valve, and short ¾ inch threaded end nipple and cap with chain.

10. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

11. Fire and Smoke Wall Penetrations: Where pipes pass through fire and smoke rated walls, partitions, ceilings, and floors, maintain the fire and smoke rated integrity. Refer to Division 23, Sections 23 05 18 and 23 05 09 for materials.

12. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals (See Section 23 05 18). Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inches and larger shall be sheet metal.

13. Anchor piping to ensure proper direction of expansion and contraction.

14. Coordinate foundation and all other structural penetrations with structural engineer.

3.3 PIPING SYSTEM JOINTS:

A. General: Provide joints of type indicated in each piping system.

B. Thread pipe in accordance with ANSI B2.1; cut threads full and clean using sharp dies. Ream threaded ends to remove burrs and restore full inside diameter. Apply pipe joint compound, or pipe joint tape (Teflon) where recommended by pipe/fitting manufacturer, on male threads at each joint and tighten joint to leave not more than 3 threads exposed.

C. Braze copper tube-and-fitting joints in accordance with ASME B31.

D. Solder copper tube-and-fitting joints with silver solder or 95-5 tin-antimony. Cut tube ends squarely, ream to full inside diameter, and clean outside of tube ends and inside of fittings. Apply solder flux to joint areas of both tubes and fittings. Insert tube full depth into fitting, and solder in manner which will draw solder full depth and circumference of joint. Wipe excess solder from joint before it hardens.

E. Weld pipe joints in accordance with ASME Code for Pressure Piping, B31. Provide weld-o-let fittings for two pipe sizes less than main pipe size.

F. Weld pipe joints in accordance with recognized industry practice and as follows:

1. Weld pipe joints only when ambient temperature is above 0 degrees F (-18 degrees C) where possible.

2. Bevel pipe ends at a 37.5 degrees angle where possible, smooth rough cuts, and clean to remove slag, metal particles and dirt.
3. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inch to 20 inch.

4. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes and non-metallic inclusions.

5. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

G. Weld pipe joints of steel water pipe in accordance with AWWA C206.

H. Flanged Joints: Match flanges within piping system, and at connections with valves and equipment. Clean flange faces and install gaskets. Tighten bolts to provide uniform compression of gaskets.

3.4 PIPING APPLICATION:

A. Accessible Fuel Gas Piping:

1. Above Grade:
   a. Exposed Location:
      1) 2 Inches and Smaller: Schedule 40, black steel pipe, beveled ends, with 150 lb. malleable iron fittings and threaded joints.
      2) Over 2 Inches: Schedule 40 black steel with butt weld fittings and welded joints.
      3) Above Ground Outside: Schedule 40 black steel pipe sizes matching above. Piping shall be painted to protect against rust.
   b. Inaccessible Location:
      1) All sizes: Schedule 40 black steel pipe, beveled ends, with socket weld fittings same thickness as pipe; welded joints.

3.5 PIPING TESTS:

A. General: Provide temporary equipment for testing, including pump and gauges. Test piping system before insulation is installed wherever feasible, and remove control devices before testing. Test each section of each piping system independently but do not use piping system valves to isolate sections where test pressure exceeds valve pressure rating. Fill each section with water and pressurize for indicated pressure and time.

B. Test all piping systems as specified. Correct leaks by remaking joints. Remove equipment not able to withstand test procedure during test.

C. Work to be installed shall remain uncovered until the required tests have been completed.

D. Piping which is to be concealed shall be tested before being permanently enclosed.

E. As soon as work has been completed, conduct preliminary tests to ascertain compliance with specified requirements. Make repairs or replacements as required.

F. Give a minimum of twenty-four hours notice to Engineer of dates when acceptance test will be conducted. Conduct tests as specified for each system in presence of representative of owner,
agency having jurisdiction or his representative. Submit copies of successful tests to the Engineer for his review. Report shall state system tested and date of successful test.

G. Contractor shall obtain certificates of approval, acceptance and compliance with regulations of agencies having jurisdiction. Work shall not be considered complete until such certificates have been delivered by the Engineer to the Owner.

H. All costs involved in these tests shall be borne by Contractor.

I. System Tests

1. Pressure test with Compressed Air or Nitrogen: For tests of this type, the piping system shall be subjected to the gas pressure indicated for that specific system. The piping capped or plugged and water-pumped with oil free air, or a nitrogen bottle shall be introduced into the entire system to the pressure specified. The system shall maintain that pressure for the duration of a soapy water test of each joint.

2. Fuel gas systems: 3 psig or 150 percent of system pressure, whichever is greater.

3.6 ADJUSTING AND CLEANING:

A. General: Clean exterior surfaces of installed piping systems of superfluous materials, and prepare for application of specified coatings (if any). Flush out piping systems with clean water before proceeding with required tests. Inspect each run of each system for completion of joints, supports and accessory items.

1. Inspect pressure piping in accordance with procedures of ASME B31.

B. Disinfect all potable water mains and water service piping in accordance with local and health department requirements. Submit test results report.

C. Clean and flush hydronic piping systems. Remove, clean, and replace strainer screens. After cleaning and flushing hydronic piping system, but before balancing, remove disposable fine mesh strainers in pump suction diffusers.

D. Chemical Treatment: Provide hydronic systems with a water analysis prepared by the chemical treatment supplier to determine the type and level of chemicals required for prevention of scale and corrosion. Perform initial treatment after completion of system testing.

3.7 COMMISSIONING:

A. Fill system and perform initial chemical treatment.

END OF SECTION 23 05 10
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of piping specialties work required by this section is indicated on drawings and schedules and by requirements of this section.

B. Piping specialties furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of piping specialties of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. FCI Compliance: Test and rate "Y" type strainers in accordance with FCI 73-1 "Pressure Rating Standard for "Y" Type Strainers". Test and rate other type strainers in accordance with FCI 78-1 "Pressure Rating Standard for Pipeline Strainers Other than "Y" Type".
   2. ASME B 31.9 "Building Services Piping" for materials, products, and installation.
   3. Safety valves and pressure vessels shall bear the appropriate ASME label.
   4. Fabricate and stamp air separators and compression tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
   5. ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualification" for qualifications for welding processes and operators.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions, and dimensioned drawings for each type of manufactured piping specialty. Include pressure drop curve or chart for each type and size of pipeline strainer. Submit schedule showing manufacturer's figure number, size, location, and features for each required piping specialty.

B. Shop Drawings: Submit for fabricated specialties, indicating details of fabrication, materials, and method of support.

C. Maintenance Data: Submit maintenance data and spare parts lists for each type of manufactured piping specialty. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   1. Pipe Escutcheons:
b. Producers Specialty & Mfg. Corp.

2. Low Pressure Strainers:
   a. Armstrong International
   b. Hoffman Specialty
   c. Metraflex Co.
   d. R-P&C Valve.
   e. Spirax Sarco.
   f. Victaulic Co. of America.
   g. Watts Regulator Co.
   h. Keckley

2.2 PIPE ESCUTCHEONS:
A. General: Provide pipe escutcheons as specified herein with inside diameter closely fitting pipe outside diameter, or outside of pipe insulation where pipe is insulated. Select outside diameter of escutcheon to completely cover pipe penetration hole in floors, walls, or ceilings; and pipe sleeve extension, if any. Furnish pipe escutcheons with nickel or chrome finish for occupied areas, prime paint finish for unoccupied areas.

B. Pipe Escutcheons for Moist Areas: For waterproof floors, and areas where water and condensation can be expected to accumulate, provide cast brass or sheet brass escutcheons, solid or split hinged.

C. Pipe Escutcheons for Dry Areas: Provide sheet steel escutcheons, solid or split hinged.

2.3 LOW PRESSURE PIPELINE STRAINERS:
A. General: Provide strainers full line size of connecting piping, with ends matching piping system materials. Select strainers for 125 psi working pressure, with Type 304 stainless steel screen. Two inches and smaller steam and liquid strainers shall have 20 mesh screens. Provide 3/64 inch perforations for 2-1/2 inch and 3 inch steam and liquid strainers. Provide 1/8 inch mesh perforations for 4 inches and larger liquid strainers. Provide 1/16 inch mesh perforations for 4 inches and larger steam strainers.

B. Threaded Ends, 2 inch and Smaller: Bronze or Cast-iron body, screwed screen retainer with centered blowdown fitted with pipe plug.

C. Threaded Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

D. Flanged Ends, 2-1/2 inches and Larger: Cast-iron body, bolted screen retainer with off-center blowdown fitted with pipe plug.

E. Butt Welded Ends, 2-1/2 inches and Larger: Schedule 40 cast carbon steel body, bolted screen retainer with off-center blowdown fitted with pipe plug.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES:
A. Pipe Escutcheons: Install pipe escutcheons on each pipe penetration thru floors, walls, partitions, and ceilings where penetration is exposed to view; and on exterior of building. Secure escutcheon to pipe or insulation so escutcheon covers penetration hole, and is flush with adjoining surface.
B. Strainers: Install strainers full size of pipeline, in accordance with manufacturer's installation instructions. Install pipe nipple and shutoff full port ball valve with ¾ inch hose end and cap in strainer blow down connection.

1. Provide strainers in supply line ahead of the following equipment, and elsewhere as indicated.
   a. Pressure reducing valves
   b. Control valves

END OF SECTION 23 05 18
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of meters and gauges required by this section is indicated on drawings and/or specified in other Division-23 sections.

B. Meters and gauges furnished as part of factory-fabricated equipment, are specified as part of equipment assembly in other Division-23 sections.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of meters and gauges, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. UL Compliance: Comply with applicable UL standards pertaining to meters and gauges.
   2. ANSI and ISA Compliance: Comply with applicable portions of ANSI and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gauges.

C. Certification: Provide meters and gauges whose accuracies, under specified operating conditions, are certified by manufacturer.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of meter and gauge. Include scale range, ratings, and calibrated performance curves, certified where indicated. Submit meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter and gauge.

B. Maintenance Data: Submit maintenance data and spare parts lists for each type of meter and gauge. Include this data and product data in Maintenance Manual; in accordance with requirements of Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

   1. Photo Voltaic Digital Thermometers:
      a. Versa Gauge
      b. Weiss Instruments
      c. Miljoco Corp.

   2. Temperature Gauge Connector Plugs:
      a. Fairfax Company
b. Peterson Equipment Co.
c. Universal Lancaster
d. Sisco
e. MG Piping Products Co.
f. Miljoco Corp.

3. Pressure Gauges:
   b. Marsh Instrument Co.; Unit of General Signal.
   c. Marshalltown Instruments, Inc.
   d. Trerice (H.O.) Co.
   e. Weiss Instruments, Inc.
   f. MG Piping Products Co.
   g. Versa Gauge
   h. Miljoco Corp.

4. Pressure Gauge Connector Plugs:
   a. Fairfax Company
   b. Peterson Equipment Co.
   c. Universal Lancaster
   d. Sisco
   e. MG Piping Products Co.
   f. Miljoco Corp.

2.2 PHOTO VOLTAIC DIGITAL THERMOMETERS:
   A. Case: High image ABS, with photovoltaic power cell and digital readout.
   B. Range: Selectable between -40-300 degrees F / -40-150 degrees F, displayed to 0.1 degrees.
   C. Accuracy: 1 percent of reading or 1 degrees F, whichever is greater. Recalibratable via internal potentiometer. Not affected by ambient temperature.
   D. Ambient light required: 10 lux.
   E. Display update: 10 seconds.
   F. Stem: Compatibly with standard thermowell for piping applications, or sampling tube with flange for air duct applications.

2.3 THERMOMETER WELLS:
   A. General: Provide thermometer wells constructed of brass or stainless steel, pressure rated to match piping system design pressure. Provide 2 inch extension for insulated piping. Provide cap nut with chain fastened permanently to thermometer well.

2.4 TEMPERATURE GAUGE CONNECTOR PLUGS:
   A. General: Provide temperature gauge connector plugs pressure rated for 500 psi and 200 degrees F. Construct of brass and finish in nickel-plate, equip with ½ inch NPS fitting, with self-sealing valve core type neoprene gasketed orifice suitable for inserting 1/8 inch O.D. probe assembly from dial type insertion thermometer. Equip orifice with gasketed screw cap and chain. Provide extension, length equal to insulation thickness, for insulated piping.
2.5 PRESSURE GAUGES:

A. General: Provide pressure gauges of materials, capacities, and ranges indicated, designed and constructed for use in service indicated.

B. Type: General use, 1 percent accuracy, ANSI B40.1 grade A, phospher bronze bourdon type, bottom connection.

C. Case: Drawn steel or brass, glass lens or acrylic, minimum 4 inch diameter.

D. Connector: Brass with 1/4 inch male NPT. Provide protective syphon when used for steam service.

E. Scale: White coated aluminum, with permanently etched markings.

F. Range: Conform to the following:
   1. Fuel Gas: 0-3 psi upstream of regulators
   2. Water: 0 - 100 psi.
   3. Fuel Gas: 0-30 in. w.c. downstream of regulators

2.6 PRESSURE GAUGE COCKS:

A. General: Provide pressure gauge cocks between pressure gauges and gauge tees on piping systems. Gauge cock shall be ½ inch female NPT on each end.

B. Syphon: ¼ inch straight coil constructed of brass tubing with ¼ inch male NPT on each end.

C. Snubber: ¼ inch brass bushing with corrosion resistant porous metal disc, through which pressure fluid is filtered. Select disc material for fluid served and pressure rating.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which meters and gauges are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF THERMOMETERS:

A. General: Install thermometers in vertical upright position, and tilted so as to be easily read by observer standing on floor.

B. Thermometer Wells: Install in piping tee where indicated, in vertical upright position. Fill well with oil or graphite, secure cap.

C. Temperature Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable temperature gauge for each plug connection.

3.3 INSTALLATION OF PRESSURE GAUGES:

A. General: Install pressure gauges in piping tee with pressure gauge cock, located on pipe at most readable position.

B. Locations: Install in the following locations, and elsewhere as indicated:
1. At suction and discharge of each pump.
2. At discharge of each pressure reducing valve.

C. Pressure Gauge Cocks: Install in piping tee with snubber. Install syphon for steam pressure gauges.

D. Pressure Gauge Connector Plugs: Install in piping tee where indicated, located on pipe at most readable position. Secure cap. Provide portable pressure gauge for each plug connection.

3.4 ADJUSTING AND CLEANING:

A. Adjusting: Adjust faces of meters and gauges to proper angle for best visibility.

B. Cleaning: Clean windows of meters and gauges and factory-finished surfaces. Replace cracked or broken windows, repair any scratched or marred surfaces with manufacturer's touch-up paint.

END OF SECTION 23 05 19
SECTION 23 05 29
HANGERS AND SUPPORTS FOR MECHANICAL PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.
   2. Duct Hangers: SMACNA Duct Manuals
   3. MSS Standard Compliance:
      a. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-69.

1.2 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

C. Product certificates signed by the manufacturer of hangers and supports certifying that their products meet the specified requirements.

D. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 23.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Pipe Hangers and Supports:
   a. B-Line Systems Inc.
   b. ANVIL International
   c. PHD Manufacturing, Inc.
   d. Unistrut Metal Framing Systems
   e. Hubbard Enterprises (Supports for domestic water piping)
   f. Specialty Products Co. (Supports for domestic water piping.
   g. Erico
   h. Grinnell
2. Saddles, Shield and Thermal Shield Inserts:
   a. ANVIL International
   b. Pipe Shields, Inc.
   c. B-Line
   d. Snapp Itz
   e. Erico
   f. Value Engineered Products, Inc.
   g. Grinnell

3. Concrete Inserts and Anchors:
   a. Unistrut Metal Framing Systems
   b. Power-Strut
   c. ITW Ramset/Red Head
   d. Hilti
   e. B-Line
   f. Erico
   g. Grinnell

2.2 PIPE HANGERS & SUPPORTS:
   A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-69.
      1. Components shall have galvanized coatings where installed for piping and equipment that will not have field-applied finish.
      2. Pipe attachments shall have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.

   B. Adjustable Clevis Hanger: MSS Type.
      1. Steel Pipe, size 3/8" thru 30", Type 1.
      2. Non-insulated Copper Pipe, size 1/2" thru 4", Type 1. (PVC Coated)

   C. Adjustable Swivel Ring for Non-insulated Pipe: MSS Type.
      1. Steel Pipe, size 1/2" thru 8", Type 7.
      2. Copper Pipe, size 1/2" thru 4", Type 7 (PVC Coated)

   D. Pipe Clamps: MSS Type.
      2. Copper Pipe, size 1/2" thru 4", Type 8 (PVC Coated).

   E. U Bolts: MSS Type.
      1. Steel Pipe, size 1/2" thru 30" Type 24
      2. Copper Pipe, size 1/2" thru 8", Type 24 (PVC Coated).

   F. Straps: MSS Type 26.

   G. Pipe Stanchion Saddle: MSS Type 37.

   H. Yoke & Roller Hanger: MSS Type 43
I. Hanger Rods: Continuous threaded steel, sizes as specified.

J. Hangers:
   1. Hot Pipes:
      a. 1/2" through 1-1/2": Adjustable wrought steel ring.
      b. 2" through 5": Adjustable wrought steel clevis.
      c. 6" and Over: Adjustable steel yoke and cast iron roll.
   2. Cold Pipes:
      a. 1/2" through 1-1/2": Adjustable wrought steel ring.
      b. 2" and Over: Adjustable wrought steel clevis.
   3. Multiple or Trapeze: Structural steel channel (with web vertical and engineered for the specific applications), with welded spacers and hanger rods. Provide cast iron roll and base plate for hot pipe sizes six inches and over. Provide hanger rods one size larger than for largest pipe in trapeze. If the deflection at center of trapeze exceeds 1/360 of the distance between the end hangers, install an additional hanger at mid-span or use a larger channel.

K. Wall Supports for Horizontal Steel Pipe:
   1. ½ inch through 4 inches: Offset or straight j-hook.
   2. 4 inches and Over: Welded steel bracket Type 31, 32 or 33 and wrought steel clamp. Provide adjustable steel yoke and cast iron roll Type 44 for hot pipe 200 degrees F and over and for sizes six inches and over.

L. Supports for Vertical Pipe: Steel riser clamp. Type 8.

M. Upper Attachments:
   1. For attaching hanger rods to structural steel I-beams:
      a. Provide adjustable beam clamp, MSS-Type 21. Attach to bottom flange of beam.
   2. For attaching hanger rods to bar joists:
      a. When bottom chord is constructed of structural steel angles, provide square washer. Place hanger rod between backs of the two angles and support with the washer and dual locking nuts on top of the angles. Spot weld washer to angles.
      b. When bottom chord is constructed of round bars, provide Elcen No. 137 bar joint washer or equal.

2.3 CONCRETE INSERTS AND ANCHORS:

A. Inserts: Case shall be of galvanized carbon steel with square threaded concrete insert nut for hanger rod connection; top lugs for reinforcing rods, nail holes for attaching to forms. This type of upper attachment is to be used for all areas having poured in place concrete construction.
   1. Size inserts to suit threaded hanger rods.

B. Provide fasteners attached to concrete ceilings that are vibration and shock resistant. Provide hangers for piping attached to concrete construction with one of the following types.
1. Concrete insert per MSS SP 69, Type 18.
2. Powder driven fasteners subject to approval of Architect and Structural Engineer. Each fastener shall be capable of holding a test load of 1000 pounds whereas the actual load shall not exceed 50 pounds.
3. Self-drilling expansion shields. The load applied shall not exceed one-fourth the proof test load required.
4. Machine bolt expansion anchor. The load applied shall not exceed one-fourth the proof test load required.

C. Anchors: Carbon steel, zinc plated and coated with a clear chromate finish. Installation shall be in holes drilled with carbide-tipped drill bits or by use of self-drilling anchors.
   1. Provide anchors suitable for the location of installation and designed to withstand all forces and movements acting in the anchor. Manufacture pipe anchors in accordance with MSS SP 69. Provide a safety factor of four for the anchor installation.

2.4 SADDLES AND THERMAL SHIELD INSERTS:
   
   A. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.
   
   B. Protection Shields: MSS Type 40; 180 degrees arc, galvanized steel, minimum 12 inches long, to prevent crushing of insulation.
   
   C. Thermal Shield Inserts: Provide 100-psi minimum compressive strength, waterproof, asbestos free calcium silicate, encased with a sheet metal enclosure. Insert and shield shall cover the entire circumference or the bottom half circumference of the pipe as required by Part 3 of this Specification, and shall be of length recommended by the manufacturer for pipe size and thickness of insulation. For cold piping, calcium silicate shall extend beyond the sheet metal shield to allow overlap of the vapor barrier. Where piping 4 inches and larger is supported on trapeze or pipe rollers, provide double thickness shields. For piping 12 inches and over, provide 600 psi calcium silicate structural insert.

2.5 MISCELLANEOUS MATERIALS:

   A. Steel Plates, Shapes, and Bars: ASTM A 36.
   
   B. Cement Grout: Portland cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix ratio shall be 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.
   
   C. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

PART 3 - EXECUTION

3.1 INSPECTION:

   A. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.
3.2 PREPARATION:

A. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments. Review Structural Drawings to obtain structural support limitations.

B. Prior to installation of hangers, supports, anchors and associated work, Installer shall meet at project site with Contractor, installer of each component of associated work, inspection and testing agency representatives (if any), installers of other work requiring coordination with work of this section and for purpose of reviewing material selections and procedures to be followed in performing the work in compliance with requirements specified. Provide Shop Drawing showing method and support locations from structure.

3.3 INSTALLATION OF BUILDING ATTACHMENTS:

A. Install building attachments within concrete or on structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

B. Existing Construction:

1. In existing concrete construction, drill into concrete slab and insert and tighten expansion anchor bolt. Connect anchor bolt to hanger rod. Care must be taken in existing concrete construction not to sever reinforcement rods or tension wires.

3.4 INSTALLATION OF HANGERS AND SUPPORTS:

A. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Arrange for grouping of parallel runs of horizontal piping to be supported together on field fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-69. Where piping of various sizes is supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate supports for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

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

C. Prevent electrolysis and abrasion in support of copper tubing by use of hangers and supports which are plastic coated, or with EPDM isolation strips. Duct tape or copper coated hangers are not acceptable.

D. Install hangers and supports to allow controlled movement of piping systems, to permit freedom of movement between pipe anchors, to facilitate action of expansion joints, expansion loops, expansion bends and similar units and within 1'-0" of each horizontal elbow.

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

F. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31.9 Building Services Piping Code is not exceeded.
G. Insulated Piping: Comply with the following installation requirements.

1. Saddles: Install Protection saddles where supported by pipe rollers. Fill interior voids with segments of insulation that match adjoining pipe insulation.
2. Shields: Install galvanized steel protection shields, on all insulated piping 2 inches and less, except where required to be clamped. Where necessary to prevent dislocation, strap shield to pipe with wire ties or "Zip Strips".
3. Thermal Inserts: Provide thermal shield inserts at all supports for all insulated piping over 2 inches and for all piping required to be clamped. Provide 180 percent inserts at clevis and roller hangers. Provide 360 percent inserts for all trapeze and clamped supports.

H. Install horizontal hydronic and steam piping with the following minimum rod sizes and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE - INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steel</td>
<td>Copper</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1-1/2</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>8</td>
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<td>3</td>
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<td>6</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>19</td>
<td>16</td>
</tr>
</tbody>
</table>

I. Install steel natural gas piping with the following minimum rod size and maximum spacing:

<table>
<thead>
<tr>
<th>SIZE (NPS)</th>
<th>MAX. SPAN IN FEET</th>
<th>MIN. ROD SIZE - INCHES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>6</td>
<td>3/8</td>
</tr>
<tr>
<td>3/4 TO 1</td>
<td>8</td>
<td>3/8</td>
</tr>
<tr>
<td>1-1/4</td>
<td>10</td>
<td>3/8</td>
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<tr>
<td>1-1/2</td>
<td>10</td>
<td>3/8</td>
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<tr>
<td>2</td>
<td>10</td>
<td>3/8</td>
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<td>3</td>
<td>10</td>
<td>½</td>
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<tr>
<td>5</td>
<td>10</td>
<td>5/8</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>3/4</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>7/8</td>
</tr>
</tbody>
</table>

J. Place a hanger within one foot of each horizontal elbow.

K. Use hangers which are vertically adjustable 1-1/2 inch minimum after piping is erected.
L. Support vertical steel and copper piping at every story height but at not more than 15 foot intervals for steel and 10 feet for copper.

M. Where several pipes can be installed in parallel and at same elevation, provide trapeze hangers.

N. Where practical, support riser piping independently of connected horizontal piping.

O. Each pipe drop to equipment shall be adequately supported. All supporting lugs or guides shall be securely anchored to the building structure.

P. Securely anchor and support plumbing domestic water piping in chases or walls. Use factory manufactured clamps and brackets connected to fixture s, waste/vent piping or brackets connected to studs. Wires or straps will not be permitted.

1. When copper supplies are connected to flush valves, support the tubing by the studs or by a fixture, not by clamping to waste/vent piping.

2. Prevent copper tubes from making contact with steel brackets using fire retardant polyethylene inserts or other dielectric insulating material. Duct tape shall not be used.

Q. Install anchors and fasteners in accordance with manufacturer's recommendations and the following:

1. In the event a self-drilling expansion shield or machine bolt expansion shield is considered to have been installed improperly, the Contractor shall make an acceptable replacement or demonstrate the stability of the anchor by performing an on-site test under which the anchor will be subjected to a load equal to twice the actual load.

3.5 INSTALLATION OF ANCHORS:

A. Install anchors at proper locations to prevent stresses from exceeding those permitted by ANSI B31.9, and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install anchor by welding steel shapes, plates and bars to piping and to structure. Comply with ANSI B31.9 and with AWS Standards D1.1.

C. Where expansion compensators are indicated, install anchors in accordance with expansion unit manufacturer's written instructions, to control movement to compensators.

D. Anchor Spacings: Where not otherwise indicated, install anchors at ends of principal pipe-runs, at intermediate points in pipe-runs between expansion loops and bends. Make provisions for preset of anchors as required to accommodate both expansion and contraction of piping. Provide shop drawing for review by Engineer.

3.6 SHEET METAL DUCT HANGERS AND SUPPORTS:

A. Provide in accordance with SMACNA HVAC duct construction standards.

3.7 EQUIPMENT SUPPORTS:

A. Fabricate structural steel stands to suspend equipment from structure above or support equipment above floor.

B. Grouting: Place grout under supports for piping and equipment.
C. Concrete bases for the mechanical equipment indoors or outdoors will be provided by the General Contractor only if shown on the architectural or structural drawings. Otherwise, all bases shall be provided by this Contractor.

D. Housekeeping bases shall be 4 inches thick minimum, extended 4 inches beyond machinery bedplates.

E. This Contractor shall be responsible for the proper size and location of all bases and shall furnish all required anchor bolts and sleeves. If bases are provided by the General Contractor, furnish him with templates showing the bolt locations.

F. Equipment shall be secured to the bases with anchor bolts of ample size. Bolts shall have bottom plates and pipe sleeves and shall be securely imbedded in the concrete. All machinery shall be grouted under the entire bearing surface. After grout has set, all wedges, shims and jack bolts shall be removed and the space filled with non-shrinking grout. This Contractor shall provide lead washers at all equipment anchor bolts.

G. Construct equipment supports above floor of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

3.8 METAL FABRICATION:

A. Cut, drill, and fit miscellaneous metal fabrications for pipe anchors and equipment supports. Install and align fabricated anchors in indicated locations.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 for procedures of manual shielded metal-arc welding, appearance and quality of welds made, methods used in correcting welding work, and the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours at welded surfaces match adjacent contours.

3.9 ADJUSTING:

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe. Cut off the bottom of threaded rods so they are no more than one rod diameter below the bottom nut.

B. Touch-Up Painting: Immediately after erection of anchors and supports, clean field welds and abraded areas of shop paint and paint exposed areas with same material as used for shop painting to comply with SSPC-PA-1 requirements for touch-up of field-painted surfaces.

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

END OF SECTION 23 05 29
SECTION 23 09 00
INSTRUMENTATION AND CONTROL FOR MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. The Contractor shall become aware of the Method of Procedure requirements outlined in Division 1. Change orders will not be considered for time associated with Method of Procedure requirements.

B. General: The Control System Contractor shall provide a complete modified control system using new control devices to replace existing devices to operate as specified. The contractor shall inspect the existing conditions prior to submitting a proposal. The existing temperature control system control devices, dampers, operators, wiring, conduit, air piping, valves, etc. not being modified and which are no longer utilized, shall be removed, and not abandoned in place.

1. All temperature control devices to be removed shall be returned to the Owner in good condition.

C. The Control Contractor will be responsible for all installation, programming, commissioning, testing and performance verification.

D. The Controls Contractor will be responsible for providing all devices required for a complete operating control system.

E. It shall be a digital, distributed microprocessor-based system with a pneumatic and electronic interface, where required. The Control System for this project will be referred to as a Building Automation System (BAS).

F. Total quantity and type of control points shall consist of specifications, drawings and as required to complete the sequence of operation as specified. Additional points shall be provided as required to meet all sequence of operation functions, safety and data base. The drawings and Specifications are not intended to show all details necessary to make the system complete and operable.

G. The Control Contractor shall be responsible for all phases of software design, all equipment, installation and warranty for the BAS. The Control Contractor shall be responsible for supplying and installing all necessary control devices for completing the BAS.

H. The system shall include all control device, valves, interlocks, field devices, hardware, software, automatic dampers, piping, fittings, wire, conduit, etc., as specified and required and connected so as to perform all functions and operate according to the specified sequences.

I. The Contractor shall leave operable existing controls in operation until the BAS is tested and proven operative. At that point, and with concurrence from the Owner and the Engineer, the Contractor shall be responsible for removing existing controls that are no longer necessary. Start-up of the BAS system, and any installation work that requires the interruption of the normal operation of any piece of equipment, shall be scheduled with the Owner. If the interruption of the normal operation of any piece of equipment during normal working hours is unacceptable to the Owner, then it shall be scheduled during after-hours (nights or weekends).

J. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner or Architect/Engineer in writing. Unless approved otherwise, all products (including firmware revisions) used in this installation shall have been used in at least twelve (12) projects prior to this installation. The previous sites may be located anywhere in the U.S.A. This requirement is not intended to restrict the Contractor to the use of any outdated equipment. Therefore, all products
used in this installation shall also be currently under manufacture and have available, for at least
10 years after completion of the contract, a complete line of spare parts. If the above requirements
are mutually exclusive, the Contractor shall include a specific statement to this effect in the Bid.

K. Refer to other Division 23 sections for installation of instrument wells, valve bodies and dampers in
mechanical systems.

L. Provide electrical work as required, complying with requirements of Division 26 sections including,
but not limited to raceways, wires, cables, electrical identification, supporting devices and electrical
connections for equipment. Work includes, but is not limited to, the following:

1. Interlock and control wiring between field-installed controls, indicating devices and unit
control panels.

2. The Contractor shall be responsible for all additional electrical and other costs involved to
accommodate the temperature control system panel, motors and electrical devices requiring
power which differs from the power requirements shown on the electrical drawings.

1.2 QUALITY ASSURANCE:

A. Contractors Qualifications: Firms regularly engaged in installation and commissioning and servicing
of digital control equipment, of types and sizes required, whose firm has been in business in similar
service for not less than 5 years.

B. Only those manufacturers specified are allowed to bid temperature controls. All bidders shall make
available, upon the Owner's request, open book unit pricing of all materials and labor.

C. The system shall be installed by competent mechanics, regularly employed by the Temperature
Control Contractor.

D. All bidders must have installed and completed at least two (2) direct digital temperature control jobs
of similar design, size and scope using the same equipment as specified.

E. All bidders must have a local office in the area of the project site.

F. All bidders must have capabilities of doing component level repairs on all systems, including
electronic systems.

G. No Field Devices shall be multiplexed to a single I/O point unless specified. Each control or sensing
point shall be terminated at a unique location on the BAS panel, Slave or Dedicated Controller and
be associated with a unique software point on the BAS.

H. Codes and Standards:

1. All equipment and the installation shall comply with the requirements of all applicable local
and national codes including but not limited to the currently enforced edition of the
International Building, International Fire, International Mechanical and all applicable codes of
the National Fire Protection Association including the National Electrical Code.

2. Electrical Standards: Provide electrical products, which have been tested, listed and labeled
by UL and comply with NEMA standards.

3. NEMA Compliance: Comply with NEMA standards pertaining to components and devices for
electric control systems.

4. NFPA Compliance: Comply with NFPA 90A “Standard for the Installation of Air Conditioning
and Ventilating Systems” where applicable to controls and control sequences.
I. All bidders must have a minimum of one person dedicated to software generation. This person shall be located in an office local to the project site.

J. The equipment and software proposed by the supplier shall be currently in manufacture. No custom products shall be allowed unless required by the Specification. All products shall be supported by the manufacturer for a minimum of 5 years including spare parts, board repairs and software revisions.

K. The Temperature Control Contractor shall cooperate with other contractors performing work on this project necessary to achieve a complete and neat installation. To that end, each contractor shall consult the drawings and specifications for all trades to determine the nature and extent of others work.

L. It will be the responsibility of the Contractor to work in cooperation with the Owner and with all other contractors and employees rendering such assistance and so arrange his work such that the entire project will be delivered complete in the best possible condition and in the shortest time.

1.3 PROPRIETARY INFORMATION:

A. Project Documentation: All custom software, programs, code, databases, graphic files and drawings (whether hard copy or CADD based files) prepared for this system shall be the exclusive property of the Owner and shall not be reproduced or distributed without prior written permission from the Owner.

B. The use or reference to the Owner or any of its subsidiaries or any of the facility automation projects shall not be used by the Manufacturer or Contractor in any promotional media, including advertisements, sale brochures, annual reports and client references or endorsements, without prior written permission from the Owner. The Owner reserves the right to restrict or refuse access to any or all of its facilities.

1.4 SUBMITTALS:

A. Submit in accordance with Division 1 and 23 submittal requirements.

B. In addition to the requirements set forth in paragraph A above, the following shall be included in the shop drawing submittals including, but not limited to:

1. Product Data: Submit manufacturer's technical product data sheets for each control device furnished, each data sheet shall be labeled indicating its control drawing descriptor and include the following:
   a. indicating dimensions;
   b. capacities;
   c. performance characteristics;
   d. electrical characteristics;
   e. finishes of materials;
   f. commissioning, installation instructions and start-up instructions.

2. Valve, damper and well and tap schedule showing size, configuration, capacity and location of all equipment.

3. Control system drawings containing pertinent data to provide a functional operating system and a sequence of operation.

4. Detailed wiring diagrams.

5. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, and all control devices. Identify all control points with labeling.
6. Label each control device with setpoint or adjustable range of control. Provide a bill of materials with manufacturer's part number.

7. Indicate all required point to point electrical wiring. Clearly differentiate between portions of wiring that are existing and portions to be field-installed.

8. Include verbal description of sequence of operation and reference each device described by schematic symbol used.

9. Provide a detailed listing of all software program code written for each system.

10. Provide a point list with database input information to include a point name, address, base and span, action and other required information.

11. Provide a detailed test plan and procedure for each HVAC system and for each type of terminal unit control including valves. The test plans shall fully define reporting methods, procedure, equipment utilized, milestones for the tests, identifying the simulation programs, and personnel. The test procedures shall be developed from the test plans and shall consist of instructions for test execution and evaluation. A test report form shall be developed for each point and sequence of operation. Commissioning procedures shall be provided for each HVAC system and for each type of terminal unit control system. The procedure shall include setpoint, prop. band, integral, derivative, mode constraints input, output settings, tuning procedures, etc.

C. Submit manufacturer's installation instructions.

D. Submittal data and shop drawings shall be prepared and submitted in the following formats:

1. All drawings prepared for the project shall be developed using the AutoCAD program, most current version, (or a CADD package capable of producing AutoCAD "DXF" compatible format files).

2. The format for different groups of submittal information are as follows:

   a. Control drawings, building plans (including complete floor plans), schematics and system configurations shall be CAD prepared drawing, bound and indexed. Drawings that cannot represent the total information on an individual ANSI size B (11" x 17") drawing, i.e. a building plan, shall be noted with appropriate match lines, cross references and key plans.

   b. Technical data, sequence of operations, material list, point lists, program listings, I/O schedules, operator's and programmer's manuals, etc. shall be type written, original product data sheets or CAD prepared drawings, ANSI size A or ANSI size B.

3. Upon completion of the project and acceptance of systems the contractor shall provide to the Owner one set of hard copy as-built shop drawings and diskettes.

E. Shop drawings shall include riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typicals will be allowed where appropriate.

F. When the Engineer requires, the Contractor will resubmit with the corrected or additional submittal data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully reviewed.

G. Contractor agrees that shop drawing submittals processed by the Engineer are not change orders, that the purpose of shop drawing submittals by the Contractor is to demonstrate to the Engineer that the Contractor understands the design concept, that he demonstrates his understanding by indicating which equipment and material he intends to furnish and install, and by detailing the fabrication and installation methods he intends to use. The Contractor shall be responsible for
space requirements, configuration, performance, changes in bases, supports, structural members and openings in structure, and other apparatus that may be affected by their use.

H. Contractor further agrees that if deviations, discrepancies, or conflicts between shop drawing submittals and the contract documents in the form of design drawings and specifications are discovered either prior to or after shop drawing submittals are processed by the Architect/Engineer, the design drawings and specifications shall control and shall be followed. If alternates do not meet these requirements, it shall be this Contractor's responsibility to remove them and install material originally specified, at no cost to the Owner.

1.5 DELIVERY, STORAGE AND HANDLING:

A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent any equipment damage, and to eliminate all dirt and moisture from equipment. Store all equipment and materials inside and protected from weather.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS AND CONTRACTORS:

A. Subject to compliance with requirements, install one of the following systems:

1. Reliable Controls

2.2 GENERAL PRODUCTS DESCRIPTION:

A. The Building Automation System (BAS) shall be capable of integrating multiple building function including equipment supervision and control, alarm management, energy management, and historical data collection and archiving. All products and materials installed shall be suitable for the intended application requirements including but not limited to:

1. Accuracy
2. Rangeability
3. Temperature and pressure ranges
4. Shut-off pressures
5. Differential pressures
6. Repeatability
7. Materials of construction suitable with the environment and/or media in which they are in contact with
8. Code compliance
9. Velocities

B. The BAS shall consist of the following:

1. Standalone DDC panels
2. Standalone application specific controllers (ASCs)
3. Portable Operator's Terminals
4. Personal Computer Operator Workstations
5. High Speed Communication Network (LAN)

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, standalone DDC panels, and operator devices.
D. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

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

F. Shared points will not be allowed.

G. BAS shall allow third party software to operate on personal computer workstation without any degradation to the controls operating normally.

2.3 NETWORKING/COMMUNICATIONS:

A. The design of the BAS shall network operator workstations and Standalone DDC panels as shown on the attached system configuration drawing. Inherent in the system's design shall be the ability to expand or modify the network either via the local area network, or auto-dial telephone line modem connections, or via a combination on the two networking schemes.

B. Local Area Network

1. Workstation/DDC Panel Support: Operator workstations and DDC panels shall directly reside on a local area network such that communications may be executed between controllers, directly between workstations, and between controllers and workstations on a peer-to-peer basis.

2. Dynamic Data Access: All operator devices, either network resident or connected via dial-up modems, shall have the ability to access all point status and application report data, or execute control functions for any and all other devices via the local area network. Access to data shall be based upon logical identification of building equipment.

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

3. General Network Design: Network design shall include the following provisions:

   a. High speed data transfer rates for alarm reporting, quick report generation from multiple controllers and upload/download efficiency between network devices. The minimum data rate shall be 1 megabit per second.

   b. Support of any combination of controllers and operator workstations directly connected to the local area network. A minimum of 50 devices shall be supported on a single local area network.

   c. Detection and accommodation of single or multiple failures of either workstations, DDC panels, or the network media. The network shall include provisions for automatically reconfiguring itself to allow all operational equipment to perform their designated functions as effectively as possible in the event of single or multiple failures.

   d. Message and alarm buffering to prevent information from being lost.

   e. Error detection, correction, and retransmission to guarantee data integrity.

   f. Default device definition to prevent loss of alarms or data, and ensure alarms are reported as quickly as possible in the event an operator device does not respond.
CONSTRUCTION DOCUMENTS
LARAMIE COUNTY COMMUNITY COLLEGE
Main Plant Boiler Burner Upgrades
December 12, 2018
Project No. 2018-336

INSTRUMENTATION AND CONTROL FOR MECHANICAL SYSTEMS

2.4 SYSTEM SOFTWARE FEATURES:
A. General
1. All necessary software to form a complete operating system as described in this specification shall be provided.
2. The software programs specified in this section shall be provided as an integral part of the DDC panel and shall not be dependent upon any higher level computer for execution.

2.5 MATERIALS AND EQUIPMENT:
A. General: The Contractor shall provide control products in the sizes and capacities indicated. The existing control system shall remain and be reused as is. Additional controllers, sensors, and devices which are required to make a complete control system shall be the responsibility of the controls contractor.

2.6 INPUTS:
A. All input accuracies required by this section shall be end-to-end (from sensing point to BAS display). End-to-end accuracy includes all errors due to the sensor, transmitter, wiring and BAS signal measurement and A/D conversion.
B. Thermistors or solid state sensors shall be provided for temperature sensing applications except where accuracies or ranges required cannot be met by these devices, RTD's shall be used. The sensors shall be powered by the BAS panel or Dedicated Controller. The solid state sensors shall be accurate to within ±0.5\,\text{deg} F over the following ranges and meet the following requirements:
1. Water Temperature Applications: 30\,\text{deg} F to 230\,\text{deg} F.
C. Where RTD's are required, they shall be 1000 ohm platinum type and be supplied with a 4-20 mA DC transmitter. The sensor and transmitter shall be a single unit. They shall be accurate to within ±1.0\,\text{deg} F over the range of 32\,\text{deg} F to 600\,\text{deg} F.
D. Where thermocouples are required, they shall be type J and be supplied with a 4-20 mA DC transmitter. They shall be accurate to within ±2.0\,\text{deg} F over the range of 32 \,\text{deg} F to 1300 \,\text{deg} F.
E. Provide matched temperature sensors for applications which require both inlet and outlet temperatures of any device.
F. Thermowells shall be monel, brass or copper for use in copper water lines; and 300 series stainless steel for all other applications.
G. Outdoor Air Temperature & Humidity Transmitter:
1. Provide Vaisala HMD60Y0 relative humidity and temperature probe with membrane filters and UV stabilized solar radiation shield. Probe shall have a temperature measuring range of
40 deg F. to +120 deg F. with an accuracy of ±0.54 deg F at 68 deg F. and relative humidity measuring range of 0 to 100% RH with an accuracy of 2% 0 to 90% RH with a repeatability better than 1% RH per year. RH and temperature probe shall be capable of a continuous temperature operating range of 40 deg F. to +120 deg F. Provide necessary transmitter for output signals.

2. Provide 1 spare set of protective filters for each transmitter Viasala No. 17039.

H. Pressure Sensors, Transmitters and Differential Switches:

1. Pump/Liquid (wet) differential pressure switches shall be as manufactured by BARKSDALE with neoprene diaphragm, stainless steel internal parts, NEMA 4 housing.
2. Air Differential Pressure Transmitters shall be Modus model T30 or T40 (as required) with an accuracy of ±1% of range (including nonlinearity and hysteresis), solid state circuitry, no moving parts, capacitance principle capable of sensing positive, negative and differential pressures. Transmitter shall have 4-20 mA output signal and be powered by the control system or dedicated controller and capable of withstanding momentary overpressure of 8 times the pressure range.
3. Differential air pressure switches for filter or proof of airflow status shall be Dwyer Series 1910, with automatic reset, SPDT.
4. Hi-static pressure safety switches shall be Dwyer series 1900 MR, with manual reset, snap switch, SPDT, with repetitive accuracy within 3%.
5. Water/Liquid/Steam/Refrigerant Pressure Transmitter: Kele & Associates Model SA, stainless pressure transmitter with 4-20 mA output signal, watertight enclosure with stainless steel bulkhead fitting, accuracy of ±1% full scale, temperature compensated, 300 series stainless steel wetted parts.
   a. Provide Model 47S pressure snubber for applications where the transmitter is subjected to fluid hammer, pressure surge or pulsation.
   b. Provide Model PT steam syphon pigtail steam applications and where the fluid temperature is higher than the maximum operating temperature rating of the transmitter.
6. Air and Vacuum Pressure Transmitter: Kele & Associates Model P100GTE, solid state, 4-20 mA signal with a full scale accuracy of 1%.

I. Output Devices:

1. Control Relays: Control relay contacts shall be rated for the application, with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage. Provide with LED to indicate status.
2. Analog output transducers shall be of positioning type with position feedback and control internal to the transducer. As an option, position feedback may also be input to the BAS.
3. Analog output transducers shall meet the following requirements:
   a. 4-20 mA DC output.
   b. Two-pipe electromechanical design or microprocessor-based design.
   c. 3-15 psi output range adjustable to a 0-20 psi range minimum.
   d. Linearity, repeatability and hysteresis no greater than 2% of full scale.
   e. Air capacity of 1000 SCIM minimum.
   f. Air consumption of no more than 100 SCIM.
   g. Pressure gauges shall be installed on the branch and supply lines.
h. Acceptable transducers are the Bellofram T1000, Fairchild T5700, Johnson N6810, Mamac EP-310 or an equivalent.

4. Electronic analog output transducers shall output a signal to match the controlled device. The Contractor shall be responsible for verifying the required signals for all controlled devices. Transducers shall be completely solid-state with no mechanical parts.

5. Time Delay Relays: Time delay relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Relays shall be equipped with coil transient suppression, devices to limit transients to 150% of rated coil voltage. Delayed contact openings or closing shall be adjustable from 1 to 60 seconds with a minimum accuracy of ±2% of setting.

6. Latching Relays: Latching Relay contacts shall be rated for the application with a minimum of 2 sets of Form C contacts enclosed in a dustproof enclosure. Relays shall be rated for a minimum life of one million operations. Operating time shall be 20 milliseconds or less, with release time of 10 milliseconds or less. Relays shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

2.7 TEMPERATURE CONTROL CABINETS:

A. General: All controllers and field interface devices shall be installed in control panel cabinet/enclosure as described below.

B. Cabinets shall be UL listed, 14 gauge furniture grade steel, finished with baked enamel painted finish inside and out, cabinet doors shall have piano hinge and standard key cylinder locking latch.

C. Control panels located outdoors shall be NEMA 4X.

D. All devices installed in or on the control cabinet shall be labeled with a fixed mounted, color contrasted, engraved laminated plastic tags, including describing the function of the device, similar to the following example:

```
ΔP
TRANSMITTER
DEVICE

Label
 DSP-1, AHU-1 SUPPLY
 DUCT STATIC
 PRESSURE TRANSMITTER
```

E. All electrical devices within the panel shall be prewired to terminal strips with all inter-device wiring within the panel completed prior to installation of the system.

F. Mount control panels adjacent to associated equipment on vibration free walls or free standing steel angle supports or "Unistrut" support stand.

2.8 VARIABLE FREQUENCY DRIVES:

A. Variable frequency drives shall be arranged so that it can be operated in an open circuit mode, disconnected from the motors, for start-up adjustments and trouble shooting.
B. Automatic operation shall be from a 4-20 milliamp signal follower, which shall follow a transducer signal. The signal follower shall contain the following design features.

1. Shall accept a transducer output signal and condition it to produce a speed reference signal for the inverter.

C. Wire all safeties to operate both in hand and auto positions as well as drive and by-pass sections.

D. Provide communication cabling and interface necessary to forward VFD computer communication information to and from the BAS/VFD. See Section 23 05 07.

2.9 ELECTRICAL MATERIALS:

A. All wiring shall be installed in conduit. See Division 26 for conduit installation requirements. Where wiring is exposed in plenum locations (i.e. open cable tray, wiring shall be plenum rated.

B. Conduit and Conductors: Types as indicated in Division 26 sized per Division 26 except for low-voltage twisted pair or single jacketed cable (1/2" minimum). All low voltage conductors shall be stranded 22 gauge copper minimum; twisted pair.

C. Fittings per Division 26: Bushings or nylon insulated throats are not required for jacketed cables.

D. All J-boxes shall be identified and labeled per Division 26.

E. All conductors and cables shall be labeled per Division 26.

F. Conduit and box supports shall be per Division 26.

G. Junction boxes shall be of types and sizes as indicated in Division 26.

H. Conduits shall not exceed 40% maximum fill for single conductor and jacketed cables.

I. Fiber Optic Cable:

1. Acceptable fiber optic cable shall include the following sizes; 50/125, 62.5/125 or 100/140. Only glass fiber is acceptable, no plastic.
2. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.

J. Coaxial Cable:

1. Coaxial cable shall conform to RG62 or RG59 rating.
2. Provide plenum rated coaxial cable when running in return air plenums.

K. All temperature control panels & controllers shall be provided with fuse protection on both incoming power load supply (primary side) and on low voltage side of control transformer (secondary side).

L. Provide lightning arresters Kele & Associates Model 392-SVSR2 or equal, at all points where communication cables exit or enter the building.

M. All communication cabling shall be shielded type.
2.10 END SWITCHES:

A. All end switches shall be NEMA rated contacts and NEMA 4X enclosure, either SPDT, DPDT DPST as required to meet the sequence of operation, complete the points list and necessary interlocks or safety control wiring. End switches shall be as manufactured by Cutler-Hammer or Allen-Bradley.

B. All end switches shall be designed and configured to provide positive indication of a control device (i.e. damper or valve) position for the service intended.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. The Contractor shall install all equipment, conduit and wiring parallel to building lines.

B. All automatic control valves and control dampers furnished by the Temperature Control Contractor shall be installed under his supervision by the Mechanical Contractor.

C. GENERAL INSTALLATION REQUIREMENTS:

1. Wiring shall be installed in conduit throughout.
2. Horizontal runs of conduit, trays, tubing or wiring shall be hung from structural members using new supports, or where feasible, utilizing existing temperature control conduit and piping. The Contractor shall verify adequacy of existing systems and warrant these systems as if they were new. Single runs of conduit, tubing or wire shall be by clevis ring and all thread rod. Multiple runs shall be by "Trapeze" or "Unistrut" supports. "Plumber's Strap" shall not be allowed. Maximum distance between supports shall be per the NEC. Existing supports shall only be used upon written concurrence by the Architect, Engineer or Owner.
3. All vertical runs of conduit or tubing shall be through new core drills. Existing core drills may be used if approved by the Owner. The installation shall be supported above each floor penetration using clamps to "Unistrut".
4. All wire that enters or leaves a building structure shall be installed with lightning protection per NEC.
5. All wire terminations shall be with compression type round hole spade lugs under a pan head screw landing; Stay-Kon or equivalent. All wire splices shall be with compression type insulated splice connectors or properly sized "wire-nut" connectors. Hand twisted, soldered and/or taped terminations or splices are not acceptable.
6. Where tubing, wiring or conduit penetrates floors or walls, sleeves with bushings shall be provided for tubing and wires. The conduit or sleeve opening shall be sealed with fire proof packing so the smoke and fire rating of the wall or floor is maintained.
7. All the material installed under this contract must be mounted on, or supported from the building structure or supports furnished by this Contractor.

D. Control Wiring:

1. Run wiring in metallic conduit, tubing or raceways. Exceptions are as follows:
   a. NEC Class 2 low voltage wiring where not exposed to view such as above suspended ceilings, in shafts, etc., may be run in cable (when approved by code authority).
   b. Wiring enclosed in temperature control panels.
2. Where conduit is used, provide steel fittings.
3. Low Voltage Conductors: 18 gauge minimum, except 19 gauge may be used for home runs to central panels and 22 gauge minimum for resistance or thermistor sensing element connections.
4. Wire control interlocks and control panels, except one 120V power circuit to each
temperature control panel shown on drawings and schedules shall be provided under Division
1.
5. All wiring shall comply with the requirements of local and national electrical codes.
6. Do not interlock alarms with starter switching to bypass alarm when equipment is manually
disconnected.
7. Variable frequency drives shall be arranged so that it can be operated in an open circuit
mode, disconnected from the motors, for start-up adjustments and trouble shooting.
8. All costs of controls, wiring conduit and associated labor shall be included in the temperature
control bid. The control wiring shall be installed under the supervision of this Contractor.

3.2 ENCLOSURES:

A. The wiring within all enclosures shall be run in plastic trays. Wiring within BAS panels may be run
using adhesive-backed tie wraps.

B. Mount all enclosures, including those which house BAS Panels, Slaves and Field Device Panels, so
that the top of the enclosure does not exceed six feet, six inches (6’-6”); and the center of any
keypad/LCD combination does not exceed five foot, six inches (5’-6”) from the floor or is less than
four feet zero inches (4’-0”) from the floor.

C. Field Device Panels contain related Field Devices such as relays, control power (24V) transformers,
output transducers, etc., that are outboard of the BAS Panels or Dedicated Controllers. Each Field
Device Panel shall be mounted within an enclosure. The enclosures shall be provided with lockable
latches that will accept a single key common to all Field Device Panels, BAS Panels and Slaves.

3.3 EXISTING CONTROLS:

A. Remove all existing controls, controllers, receiver/controllers, thermostats, sensors, Field Devices,
gauges, etc.; and all associated wiring, piping and mounting hardware whose functions are being
replaced by the BAS.

1. When existing equipment is removed, coordinate with a detailed Method of Procedure (MOP).
2. Do not remove until Owner reviews.
3. Refer to General Conditions.

3.4 INSTALLATION PRACTICES:

A. The Contractor shall install and calibrate all Field Devices, sensors and transducers necessary for
the complete operation of the I/O points described herein.

B. Sensors shall be removable without shutting down the system in which they are installed.

C. All immersion sensors shall be installed in new, welded thermowells supplied by the Contractor.
Existing thermowells may be reused with concurrence from the Owner. Coordinate any required
shutdown with Owner.

D. Thermistor wire leads shall be permanently terminated at panels or controllers with wire clamps.

E. Where none exist, furnish and install pressure/temperature gauges adjacent to each immersion type
sensor.

F. Sensors shall be installed with the use of a wet or hot tap without draining the system if required.
3.5 **IDENTIFICATION:**

A. All control J-boxes, conduit and wiring shall be labeled.

B. Electrical devices, wiring, conduit and J-boxes shall be labeled and identified as required by Division 26.

   1. As a minimum regardless of Division 26 requirements, all temperature control J-box covers shall be painted blue in color on both sides of cover.

3.6 **LOCATIONS:**

A. All sensing devices and locations shall be located by the Contractor as shown on the submittal shop drawings with final review by the Engineer.

B. Wall mount space sensors shall be mounted five (5) feet above finished floor. Pendant mount space sensors shall be mounted eight (8) feet above finished floor.

C. Enclosures housing Field Devices shall be located immediately adjacent horizontally to the BAS panels or Slaves which are being interfaced to.

3.7 **VALVES, WELLS, FLOW SWITCHES AND AUTOMATIC CONTROL DAMPERS:**

A. The Controls Contractor shall have his control equipment on the project site when required and give the Owner 24 hour written notice when systems must be shut down for installation.

3.8 **TEMPERATURE SENSORS:**

A. Temperature sensors shall be mounted on suitable insulated base and secured to the wall in such a way as to be easily removed from wall without damage to the sensor.

B. Check and verify location of thermostats and other exposed control sensors with plans and room details before installation. Locate thermostats 48" (1524 mm) above floor.

3.9 **EQUIPMENT PROTECTION AND COORDINATION:**

A. Where existing walls are penetrated with conduit or piping, provide a fire stop assembly which meets or exceeds the original rating of the assembly. Refer to Division 23.

B. Extreme care must be exercised while working in existing facilities and around operating equipment. Close coordination with the Owner is required for the protection of this operating equipment from dust, dirt and construction material while maintaining the operational environment for the equipment. Under no circumstances shall the power or environmental requirements of the operating equipment be interrupted during the installation and check-out without submitting to the Owner and Engineer for approval.

C. A detailed Method of Procedure (MOP) stating the steps to be taken, time schedule and impacted systems for the service interruption shall be submitted to the Architect for approval prior to beginning work. Refer to Division 1 and Division 23 for requirements.

3.10 **CLEANUP:**

A. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned and all other areas shall be cleaned around equipment provided under this
contract. Clean the exposed surfaces of tubing, hangers, and other exposed metal of all grease, plaster, dust, or other foreign materials.

B. Upon final completion of work in an area, vacuum and/or damp wipe all finished room surfaces and furnishings. Use extreme care in cleaning around telephone switching and computer equipment and under no circumstances shall water or solvents be used around this equipment.

C. At the completion of the work and at the end of each work day, remove from the building, the premises, and surrounding streets, etc., all rubbish and debris resulting from the operations and leave all equipment spaces absolutely clean and ready for use.

3.11 SOFTWARE, DATABASE AND GRAPHICS:

A. Software Installation: The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third party software necessary for successful operation of the system.

B. Database Configuration: The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphics: Unless otherwise directed by the Owner, the Contractor will provide color graphic displays for all systems which are specified with a sequence of operation, depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the Owner.

3.12 START UP AND TESTING:

A. Prior to Beneficial Use of the BAS, the Contractor shall supply to Architect/Engineer two (2) debugged printouts of all software entered into the BAS. Also supply all users programming and engineering manuals required to interpret the software. Included in the printouts, though not limited to, shall be the following:

1. Point data base.
2. All custom control programs written in the BAS control language.
3. All parameters required for proper operation of BAS control and utility firmware such as start-stop routines, etc.
4. Printouts or plotted detailed copies of the complete interactive system graphics.

B. The software printout shall be fully documented for ease of interpretation by the Engineer and Owner, without assistance from the Contractor. English language descriptions shall be either integrated with or attached to the BAS printout. Specifically, the following shall be documented:

1. All point (I/O and virtual) names.
2. All BAS Programming Language commands, functions, syntax, operators, and reserved variables.
3. Use of all BAS firmware.
4. The intended actions, decisions, and calculations of each line or logical group of lines in the custom control program(s). Sequences of operation are not acceptable for use in this documentation requirement.
5. Complete descriptions of and theories explaining all software and firmware algorithms. The algorithms to be described include, but are not limited to, PID, optimum start/stop, demand limiting, etc.

C. Documentation that was supplied as part of the submittals need not be submitted at this time.
D. Upon review of software, a point-to-point test of the BAS installation shall commence. The Contractor shall provide two men equipped with two-way communication and shall test actual field operation of each control and sensing point. This procedure shall occur during off hour periods. The purpose is to test the calibration, response, and action of every point. Any test equipment required to prove the proper operation of the BAS shall be provided by and operated by the Contractor. The Engineer and/Owner will be present to oversee, observe, and review the test. Demonstrate compliance that system functions per the Sequence of Operation.

1. Upon review of the point-to-point demonstration, the Contractor shall start up the BAS by putting all controlled equipment in automatic and enabling software. Contractor shall commence final software and overall BAS hardware/software debugging.
2. The point-to-point demonstration shall include any existing BAS equipment if it affects the operation of the equipment included under this contract.
3. As a minimum, existing conditions shall be maintained during system changeover.

E. Final acceptance of the BAS is contingent upon a hardware/software system test. All groups of points that yield a system of control shall be tested for compliance with the sequences of operation. Included in the test, but not limited to, shall be:

1. BAS loop response. The Contractor shall supply a trend data output in graphical form showing the step response of each BAS loop. The test shall show the loop's response to a change in set point which represents a change in the actuator position of at least 25% of its full range. The sampling rate of the trend shall be from one to three 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 does not yield temperature control of + 0.2 deg F or humidity control of + 3% RH shall require further tuning by the Contractor.
2. Interlocks and other sequences.
3. BAS control under HVAC equipment failure.
4. HVAC operation under BAS equipment failure.
5. Battery backup.
6. BAS control under power failure/restart.
7. Reset schedules.
8. BAS alarm reporting capability.

F. A detailed test report as defined under Submittals shall be provided indicating its completion and proper system operation.

G. The BAS will not be accepted as meeting the requirements of Beneficial Use until all tests described in this section have been performed to the satisfaction of the Engineer and Owner. Any tests that cannot be performed due to circumstances beyond the control of the Contractor shall be exempt from the Beneficial Use requirements if requested in writing by the Contractor and concurred by the Owner and Engineer. Such tests shall be performed as part of the BAS warranty.

1. A typed written document stating that the system has been fully checked out on a point by point basis shall be submitted to the Engineer. All documentation associated with the checkout shall be included.

3.13 PROJECT RECORD DOCUMENTS:

A. The Contractor shall be responsible for updating all existing Project Record Documents associated with the Scope of Work outlined in the Drawings and Specifications.

B. Prior to final completion of the installation, prepare a complete set of record drawings. The content, format and procedure of the submittal shall be as described by the General Conditions.
C. Prior to final completion of the installation, prepare operation and maintenance manuals. The information is to be inserted in the existing operation and maintenance manuals or provided in a tabbed and indexed.

3.14 WARRANTY:

A. The Warranty period shall begin on the date of beneficial use completion as authorized by the Engineer and Owner in writing. Beneficial use shall not occur before the Contractor has performed the tests required. With these requirements met, beneficial use shall not occur until, in the opinion of the Engineer, the BAS is sufficiently complete to be utilized for the purposes for which it is intended.

1. The warranty start date shall not begin until all phases of the Project are complete, i.e., the Project shall have a single warranty start date.

B. The BAS system shall be guaranteed to be free from defects in material and workmanship and in software design and operation for a period of the warranty after completion of the project. The Contractor shall provide the necessary skills, labor, and parts to assure the proper operation of, and to provide all required current and preventive maintenance. This warranty shall become effective starting the date of Beneficial Use completion.

1. The hardware warranty shall include all equipment which has been purchased by the Contractor. The existing hardware is not subject to the warranty requirements.
2. All software work completed by the Contractor, associated with existing hardware, is subject to the warranty requirements outlined herein.
3. The Contractor shall respond to all calls during the warranty period for all problems or questions experienced in the operation of the installed equipment and shall take steps to correct any deficiencies that may exist.
4. The response time to any problems shall be four (4) hours maximum 24 hours per day, 7 days per week. Corrective action, temporary or permanent shall be made within one business day.

C. The Contractor shall provide 4 hours of training for the building operators. The training session shall be made available to the Owner prior to the end of the warranty period but after final completion of the contract. The session shall be given at the Owner's facility. Scheduling shall be approved by the Owner. The training shall focus on general design, operation, and maintenance procedures of the products installed, though not necessarily the specific system designed, and shall cover:

1. Hardware configuration including PC boards, switches, communication and point wiring, and location and installation of all sensors and control devices.
2. Hardware maintenance, calibration, troubleshooting, diagnostics, and repair instructions.
3. Operation of man-machine interface including logging on/off, interrogating the system, producing reports, acknowledging alarms, overriding computer control, and changing firmware/software parameters.
4. Programming the BAS using the editor and the design of custom control software.
5. Recovery procedures from both BAS and HVAC failures.

D. The Instructor for the above session shall be an employee of the Contractor, who is qualified to provide customer training and applications support.

END OF SECTION 23 09 00
PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section applies to all fuel gases on the project. This includes natural gas and liquefied petroleum gas (LPG).

1.2 DEFINITIONS:

A. Pipe sizes used in this Specification are Nominal Pipe Size (NPS).

B. Gas Distribution Piping: A pipe within the building which conveys gas from the point of delivery to the points of usage.

C. Gas Service Piping: The pipe from the gas main or other source of supply including the meter, regulating valve, or service valve to the gas distribution system of the building served.

D. Point of Delivery is the outlet of the service meter assembly, or the outlet of the service regulator (service shutoff valve when no meter is provided).

1.3 SUBMITTALS:

A. Product data for each gas piping specialty and special duty valve. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.

B. Shop drawings detailing dimensions, required clearances, for connection to gas meter.

C. Record Drawings: At project closeout, submit record drawings of installed systems products; in accordance with requirements of Division 23.

D. Maintenance data for gas specialties and special duty valves, for inclusion in operating and maintenance manual specified in Division 23.

E. Welders' qualification certificates, certifying that welders comply with the quality requirements specified under "Quality Assurance" below.

F. Test reports specified in Part 3 below.

1.4 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of natural gas systems products, of types, materials, sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Installer Qualifications: Installation and replacement of gas piping, gas utilization equipment or accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified is defined as experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope to this project), familiar with precautions required, and has complied with the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Architect.
C. Qualifications for Welding Processes and Operators: Comply with the requirements of ASME Boiler and Pressure Vessel Code, "Welding and Brazing Qualification."

D. Regulatory Requirements: Comply with the requirements of the following codes:

1. NFPA 54 - National Fuel Gas Code, for gas piping materials and components, gas piping installations, and inspection, testing, and purging of gas piping systems.
2. Local Building Code.
3. Utility Compliance: Fabricate and install natural gas systems in accordance with local gas utility company.

1.5 DELIVERY, STORAGE, AND HANDLING:

A. Handling Flammable Liquids: Remove and legally dispose of liquid from a drip in existing gas piping and handle cautiously to avoid spillage or ignition. Notify the gas supplier. Handle flammable liquids used by the installer with proper precautions, and do not leave on the premises from the end of one working day to the beginning of the next.

1.6 SEQUENCING AND SCHEDULING:

A. Notification of Interruption of Service: Except in the case of an emergency, notify all affected users when the gas supply is to be turned off.

B. Work Interruptions: When interruptions in work occur while repairs or alterations are being made to an existing piping system, leave the system in safe condition.

C. Coordinate the installation of pipe sleeves for foundation wall penetrations.

1.7 EXTRA MATERIALS:

A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Gas Cocks:
   a. Jenkins Bros.
   b. Lunkenheimer Co.
   c. Nibco, Inc.
   d. Powell Co.
   e. Stockham.

2.2 PIPE, TUBING AND JOINTING MATERIALS:

A. Provide pipes and pipe fitting complying with Division 23, Section 23 05 10 “Basic Piping Materials and Methods”.

2.3 NATURAL GAS PIPING SPECIALTIES:

A. Protective Coating: Provide factory applied polyethylene tape, having the following properties:
1. Overall thickness; 20 mils.
2. Synthetic adhesive.
3. Water vapor transmission rate.
4. Gallons per 100 square inch: 0.10 or less.
5. Water absorption, percent: 0.02 or less.
6. Prime pipe and fittings with a compatible primer prior to application of tape.
7. Pipe wrapping shall conform to the following schedule:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Tape Width</th>
<th>Scotchwrap No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Cold</td>
</tr>
<tr>
<td>1/4 - 3/4 inch</td>
<td>1 inch</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>1 - 1-1/2 inch</td>
<td>2 or 4 inch</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>2 inch and larger</td>
<td>4 inch</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Color backing</td>
<td></td>
<td>Black</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green</td>
</tr>
</tbody>
</table>

8. During application of wrap, if the ambient temperature is 40 degrees F or less, use only Scotchwrap No. 40 tape. If ambient temperature is 40 degrees F or more, use only Scotchwrap No. 50.

B. Flexible Connectors: Corrugated type 304 stainless steel flexible pipe with stainless steel braid and heavy flexible armor shield.

2.4 VALVES:

A. Special duty valves are specified in this section by their generic name. Refer to Part 3, "VALVE APPLICATION," for specific uses and applications for valve specified.

B. Gas Cocks 2 Inch and Smaller: 150 psi WOG, bronze body, straightaway pattern, square head, threaded ends.

C. Gas Cocks 2-1/2 Inch and Larger: MSS SP-78; 175 psi, lubricated plug type, semi-steel body, single gland, wrench operated, flanged ends.

D. Gas Line Pressure Regulators: Single stage, steel jacketed, corrosion-resistant gas pressure regulators; with atmospheric vent, elevation compensator; with threaded ends for 2 inch and smaller, flanged ends for 2-1/2 inch and larger; for inlet and outlet gas pressures, specific gravity, and volume flow indicated.

PART 3 - EXECUTION

3.1 INSPECTION:

A. General: Examine areas and conditions under which natural gas systems materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.
3.2 PREPARATION:

A. Precautions: Before turning off the gas to the premises, or section of piping, turn off all equipment valves. Perform a leakage test as specified in "FIELD QUALITY CONTROL" below, to determine that all equipment is turned off in the piping section to be affected.

B. Conform to the requirements in NFPA 54, for the prevention of accidental ignition.

3.3 INSTALLATION OF PIPE:

A. Install natural gas piping in accordance with Division 23, Section 23 05 10.

B. Conform to the requirements of NFPA 54 - National Fuel Gas Code.

C. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of piping systems. Design locations and arrangements of piping take into consideration pipe sizing, flow direction, slope of pipe, expansion, and other design considerations. So far as practical, install piping as indicated.

D. Install pipe sleeve and seals at foundation and basement wall penetrations, as specified in Division 23 Section 23 05 10 "Basic Piping Materials and Methods."

E. Seal pipe penetrations of fire barriers using fire barrier penetration sealers specified in Division 23.

F. Drips and Sediment Traps: Install a drip leg at points where condensate may collect, at the outlet of the gas meter, and in a location readily accessible to permit cleaning and emptying. Do not install drips where condensate is likely to freeze.

1. Construct drips and sediment traps using a tee fitting with the bottom outlet plugged or capped. Use a minimum of 3 pipe diameters in length for the drip leg. Use same size pipe for drip leg as the connected pipe.

G. Use fittings for all changes in direction and all branch connections.

H. Install gas piping at a uniform grade upward to risers, and from the risers to the meter, or service regulator when meter is not provided, or the equipment.

I. Connect branch outlet pipes from the top of horizontal lines, not from the bottom or sides.

3.4 NATURAL GAS PIPING SPECIALTIES:

A. Protective Coating:

1. Provide protective coating on piping and fittings that will be in contact with material or atmosphere exerting a corrosive action, or piping buried in floors. Protective coating shall be applied at the factory.

3.5 VALVE APPLICATIONS:

A. General: The Drawings indicate valve types, locations, and arrangements.

B. Shut-off duty: Use gas cocks.
3.6 VALVE INSTALLATIONS:
   A. Install valves in accessible locations, protected from physical damage. Tag valves with a metal tag attached with a metal chain indicating the piping systems supplied.
   B. Install a gas cock upstream of each gas pressure regulator. Where two gas pressure regulators are installed in series in a single gas line, a manual valve is not required at the second regulator.
   C. Install pressure relief or pressure limiting devices so they can be readily operated to determine if the valve is free; so they can be tested to determine the pressure at which they will operate; and examined for leakage when in the closed position. Pipe atmospheric vent to outdoors.
   D. Valves shall be installed with unions or other means to facilitate removal or repair without disassembly of connecting piping.

3.7 TERMINAL EQUIPMENT CONNECTIONS:
   A. Install gas cock upstream and within 6 feet of gas appliance. Install a union or flanged connection downstream from the gas cock to permit removal.
   B. Sediment Traps: Install a tee fitting with the bottom outlet plugged or capped as close to the inlet of the gas appliance as practical. Drip leg shall be a minimum of 3 pipe diameters in length.
   C. Flexible Hose Gas Connectors: For use connecting to vibrating equipment; corrugated Type 304 stainless steel flexible pipe with stainless steel braid.

3.8 ELECTRICAL BONDING AND GROUNDING:
   A. Install above ground portions of gas piping systems, upstream from equipment shutoff valves electrically continuous and bonded to a grounding electrode in accordance with NFPA 70 - "National Electrical Code."
   B. Do not use gas piping as a grounding electrode.
   C. Conform to NFPA 70 - "National Electrical Code," for electrical connections between wiring and electrically operated control devices.

3.9 FIELD QUALITY CONTROL:
   A. Piping Tests: Inspect, test, and purge natural gas systems in accordance with NFPA 54, and local utility requirements.
   B. Test system before covering underground lines.
   C. Submit written results of tests to Architect/Engineer.

3.10 SPARE PARTS:
   A. Valve Wrenches: Furnish to Owner, with receipt, 2 valve wrenches for each type of gas valve installed, requiring same.

END OF SECTION 23 11 23
SECTION 23 51 00
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Field-fabricated metal breechings and chimneys.

1.2 SUBMITTALS

A. Product Data: For the following:

1. Chimney liners.
2. Type B and BW vents.
3. Type L vents.
4. Special gas vents.
5. Building-heating-appliance chimneys.
7. Refractory-lined metal breechings and chimneys.
8. Guy wires and connectors.
9. Barometric Dampers

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, anchoring requirements, expansion compensation, pressure relief devices, components, hangers and seismic restraints, and location and size of each field connection.
2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Welding certificates.

1.3 QUALITY ASSURANCE


PART 2 - PRODUCTS

2.1 FIELD-FABRICATED METAL BREECHINGS AND CHIMNEYS

A. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction"

B. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 1.069 Sq. Ft. or 14 Inches in Diameter: 0.053 inch.
2. Up to 1.396 Sq. Ft. or 16 Inches in Diameter: 0.067 inch.
3. Up to 1.764 Sq. Ft. or 18 Inches in Diameter: 0.093 inch.
4. Larger Than Above: 0.123 inch.

C. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

3.3 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS AND CHIMNEYS

A. Suspend breechings and chimneys independent of their appliance connections.
B. Install, support, and restrain according to seismic requirements.
C. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch misalignment tolerance.
D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
E. Lap joints in direction of flow.
F. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

3.4 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 00
SECTION 23 52 00
HEATING BOILERS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. Extent of boiler work required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Refer to other Division 23 sections for piping, specialties, water treatment, pumps, breechings, temperature controls, etc., required external to boilers for installation; not work of this section.

C. Electrical Work: Refer to Division-23 section "Electrical Provisions of Mechanical Work" for requirements.

D. Electrical Work: Provide the following wiring as work of this section, in accordance with requirements of Division 16:

1. Furnish to Electrical Installer, burner emergency shutoff switch.

2. Provide control wiring between boiler control panel and thermostats, aquastats, pressurestats, or any other control device.

3. Provide factory-mounted and wired controls and electrical devices as specified in this section.

E. Refer to Division-16 sections for other electrical work including motor starters, disconnects, wires/cables, raceways, and other required electrical devices; not work of this section.

1.2 QUALITY ASSURANCE:

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of boilers, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Manufacturer's Test: All boilers and burners shall be factory assembled and tested. Submit test results to Architect/Engineer prior to shipping.

C. Codes and Standards:

1. Burners:

   a. Control devices and control sequences: In accordance with requirements Of Industrial Risk Insurers (IRI).

   b. Installation standards: Oil-fired boilers shall be in accordance with National Fire Protection Association (NFPA) Standard 31 "Standard for the Installation of Oil Burning Equipment".

d. Ancillary electrical components shall be Underwriters Laboratories (UL) listed and labeled.

1.3 SUBMITTALS:

A. Product Data: Submit manufacturer's technical product data, including rated capacities of selected model clearly indicated, weights (shipping, installed, and operating), furnished specialties, and accessories; and installation and start-up instructions.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weights, loadings, required clearances, and method of field assembly, components and location and size of each field connection.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to cast-iron boilers. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring required for final installation of cast-iron boilers and controls. Clearly differentiate between portions of wiring that are factory installed and portions to be field-installed.

D. Record Drawings: At project closeout, submit record drawings of installed systems products in accordance with requirements of Division 23.

E. Maintenance Data: Submit maintenance data and parts list for each cast-iron boiler, control, and accessory; including "trouble-shooting" maintenance guide. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual; in accordance with requirements of Division 23.

1.4 DELIVERY, STORAGE, AND HANDLING:

A. Handle boiler sections and equipment carefully to prevent damage, breaking, and scoring. Do not install damaged sections or components; replace with new.

B. Store boiler sections and equipment in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

C. Comply with manufacturer's rigging and moving instructions for unloading boilers, and moving them to final location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

   1. Dual Fuel Burner:
      a. Riello
      b. Weishaupt
      c. Limpsfield

2.2 DUAL FUEL BURNERS:
A. General Requirements:

1. Furnish and install UL listed dual fuel gas fired burners. Burner(s) construction, design, components and installation shall adhere to all applicable code requirements. The burners, gas train and fuel oil train shall comply with NFPA 85.

2. The burner shall be mounted to fire on the centerline of the boiler furnace tube. A new refractory front plate in accordance with the burner manufacturer’s instructions will be provided.

3. Each boiler shall be equipped with a factory packaged combustion system complete with fuel supply system, fuel/air ratio controls and integrally mounted or remote mounted controls.
   a. Burner Description:
      1) Provide a forced draft flame retention type automatic burner. The burner(s) shall be designed to fire as scheduled.
      2) Burner operation will be full modulation on natural gas and LPG gas. Burner shall operate with minimal vibration and noise at the specified rate. The burner must operate with 15% – 20% excess air and CO must be less than 50 ppm in the products of combustion.

4. All components on burner shall have a minimum 24-month warranty from day of start-up.

B. Burner Construction

1. Burner housing shall be cast aluminum monobloc type construction. The burner mounting flange must support the burner weight on the boiler independent of any support.

2. Burner shall be furnished with a stainless steel flame retention type of combustion head, capable of withstanding temperatures up to 1400°F. This combustion head shall incorporate a diffuser and sleeve that is to direct excess air either around the flame or directly through the diffuser vanes. Adjustment to the diffuser insertion shall be made external to the burner and can be made while burner is in full operation.

3. Burner shall be equipped with hinged head mount that allows for full access to the burner drawer assembly without removing the burner chassis from the boiler.

4. Burner must have a flame inspection window positioned at the rear center of the burner housing. Flame shall be viewed without removing any covers.

5. Burner shall come complete with a high efficiency, totally enclosed fan cooled motor (TEFC) and a dynamically balanced blower wheel. The blower wheel must be of the energy efficient, self-cleaning, reverse inclined fan blade type.
6. The sound rating of the burner shall not exceed 80 dBA when measured at 3 feet from the burner.

C. Fuel/Air Ratio Control

1. Burner must be outfitted with a integral Camnetic characterized fuel/air metering system. The system shall be capable of providing an adjustable and accurately repeatable constant fuel/air ratio or a linearly adjusted fuel/air ratio throughout the burner’s firing range. Each system shall be complete with independently electronically adjustable cam set-points.

2. There shall be a maximum of two turnbuckle design linkage rods on the burner; one used to position an integral burner mounted spring loaded characterized gas butterfly valve that will spring snap to the closed position if the linkage rod was to be disconnected. The other linkage to control the single blade combustion air damper, located on the suction side of the combustion air intake housing.

3. A protection screen must be installed on the air intake housing.

4. Metering system shall be control by a single servomotors, Siemens model SQM 450, with multiple eight individually adjustable programming points microswitches to enable the service technician to easily set the following positions to control the parameters of the burner.

5. The servomotor shall perform the following:
   a. Shut down position (damper positioned closed at 0° when the call for heat is satisfied)
   b. Independent gas ignition position
   c. Low fire gas position
   d. High fire gas position

6. Servomotor motors must be adjustable to any setting from fully closed to fully open.

7. Servomotor shall provide auto position recognition.

8. The burner management system servomotor shall have the capability of receiving the following signals directly from the boiler temperature or pressure controller without the use of an external signal converter for gas/oil operation.
   a. 0–10Vdc
   b. 0 – 135Ω
   c. 4–20mA
   d. 0-20mA

9. The burner management system servomotor shall be capable of generating an output signal based on any of the above mentioned input signals with the exception of position proportioning.
10. When the operating control is satisfied the burner shall shutoff and return to the closed position. The modulating motor shall provide an electrical interlock to insure a guaranteed low fire start.

D. Ignition and Flame Proving Systems:

1. The burner gas ignition system for the main gas shall utilize natural gas and LPG gas as the fuel source. The gas pilot system components shall include spark ignited pilot assembly, 7000 Volt ignition transformer, pilot safety shut off valve, pilot gas pressure regulator and manual gas shutoff cock.

E. Burner Mounted Controls

1. Burner shall be equipped with an integral burner mounted control panel consisting of necessary motor starters, overloads, lights and switches. Burner shall be supplied with an integral AUTO/MANUAL/OFF switch that incorporates a control toggle that will allow a technician to manually drive the burner servomotor from low fire to high fire or high fire to low fire and the means to stop at any position in between, in a smooth and controlled method.

2. To insure safety valves for the two fuels cannot be energized at the same time a relay shall be used to isolate fuel valves for both fuels.

F. Flame Safeguard Siemens

1. Burner mounted flame management control shall be a UL/FM approved, Siemens MV52.

2. The control must perform and include the following:
   a. Should the burner go to a safe lockout position due to ignition or flame failure no attempt at re-ignition will take place without manually resetting the control.
   b. The control shall have an internal fuse to protect against power surges and short circuits. This fuse shall be easily replaced in the field by a qualified service technician. There must be a spare fuse located in control.
   c. The control shall have a built in LED type annunciator, which indicates the position of the burner firing sequence.
   d. The reset switch shall be located on the front display of the control. The switch fault shall illuminate during a lock out condition.
   e. In the event of a power failure the control shall not lock out, and once power is restored the control will perform a safe start-up upon a call for steam.

G. Main Gas Train:
1. U.L. Requirements
   a. The gas valve train shall contain the following:
      1) Manual Shutoff cock
      2) Main gas pressure regulator “tight shutoff type” when gas supply pressure exceeds 1 PSIG.
      3) Two automatically operated safety shut-off valves one with valve seal over-travel and proof of closure switch when capacity is over 5.0 MBH.
      4) Manual reset low and high gas pressure switches.
      6) Burner manifold gas pressure gauge.

2. IRI Requirements:
   a. U.L. listed leak test cock.
   b. Both automatically operated safety shut off valves (main and auxiliary) shall have motorized operators, one with valve seal over travel and proof of closure.
   c. One normally open vent valve sized according to IRI requirements.
   d. Manual reset low and high gas pressure switches (specify for all burner capacities).

H. Modulating Burner/Boiler Control:

1. Temperature/Pressure Controller: Controller shall be Siemens RWF40 PID or equivalent. The controller shall be microprocessor based with UL, CSA, and CE approvals. The controller shall have a digital LED display and shall continuously display both the set point and the actual process temperature/pressure. The controller shall have different color LED displays to readily distinguish between the set point and the process variable. The controller’s display face shall be NEMA 4 rated.

2. The controller shall have a fully modulating PID control output, and shall be configurable as a fully modulating output for dual fuel. The controller shall have a manual control mode and visual indicator on the display face to indicate manual operation.

3. In addition to controlling the process variable (temperature or pressure), the controller shall provide the operating limit control function. A visual indicator on the display face shall annunciate the limit control contact closure. The lower and upper set point deviations to turn the burner on and off shall be independently configurable.

4. The controller shall utilize a proportional, integral, and derivative (PID) control logic to determine the modulating output. The controller shall have an ‘auto-tune’ feature for optimization of
the PID parameters. The controller shall be capable of accepting specific PID parameters manually. The controller shall be capable of accepting either temperature or pressure sensor inputs to monitor the process variable. The controller shall accept all common inputs including resistance thermometers (two and three wire Pt100, Pt1000, Ni100, and Ni 1000), thermocouples (type J, K, T, and N), analog current signals (0-20 mA and 4-20 mA), and analog voltage signals (0-1 Vdc and 0-10 Vdc). The analog current and voltage signals must be readily scalable to display the actual temperature in degrees Fahrenheit, or pressure in psi.

5. The controller shall have an adjustable set point capable of being adjusted via buttons on the controller’s display face or remotely via an analog input from a building/boiler room management system. The remote set point input shall have the capability of accepting a 0-1000 ohm, 0-1 Vdc, 0-10 Vdc, 0-20 mA, or 4-20 mA analog signal.

6. The controller shall have an additional input to accept a Ni1000 or Pt1000 temperature sensor used to reset the set point based on outdoor temperature. The outdoor temperature set point shift shall have a time averaging feature to dampen the effects of sudden/temporary temperature changes. The controller shall have configurable set point limits to prevent the operator (or remote set point signal) from adjusting the set point outside the configured set point limits. The controller shall have three levels of security to lockout some or all of the parameters. All configuration data must be internally stored in non-volatile EEPROM memory giving indefinite power failure protection.

7. The controller shall have a configurable, ‘intelligent’ function to minimize burner on/off cycling. The controller shall recognize when the demand on the boiler is less than the low-fire output, and automatically hold the burner at low-fire to ensure the minimum number of on/off cycles. Should the demand increase while in low fire hold, the controller shall recognize this change and release the burner to modulate.

8. The controller shall have a configurable alarm contact. A visual indicator on the display face shall indicate contact closure. The contact actuation shall be configurable for high limit, low limit, or set point deviation. Contact actuation shall be configurable to correlate to the process variable input, outdoor temperature sensor input, or remote set point signal input. Contacts must be configurable to actuate in the open or closed position. Each contact function shall have an adjustable deviation band and configurable set point. Upon sensor failure, contacts shall be configurable to failsafe in either the open or closed position.

9. The controller shall have the ability to monitor an external set of contacts, and shift (by a configurable value) or change (to a specific temperature/pressure) the set point when the contacts are closed. These contacts may be utilized to perform night setback, set point shift/change functions. The controller shall be capable of accepting a power source ranging from 100 to 240 Vac voltage / 48-63 Hz frequency. Controller shall provide an integral 24 Vdc (30 mA max. rating) power output to power the process variable sensing device (i.e., pressure transducer).

2.3 OVERFIRE DRAFT CONTROL SYSTEM

A. The contractor shall furnish and install a UL approved Draft Control System as manufactured by US Draft Co or approved equal. The controller shall be installed in a factory panel and must have four pushbuttons on the front panel for all operator functions such as alarm.
acknowledgement, selection of displays and control functions. The display must include set points and tuning parameters and operational values such as flue gas temperature, draft pressure and alarms.

1. The controller must sense the draft pressure by means of a bi-directional pressure transducer.
2. The controller should modulate to maintain a constant pressure throughout the firing rate of burner/boiler.
3. The controller must be field configurable for selecting the sequencing with post and pre-purge capability and for positive or negative set point.
4. The controller must include a closed/auto/open selector switch and all necessary relays for full programming and control actions. The “closed” position will bypass all automatic functions and close the damper. The “open” position will open the damper and the boiler can be operated in the case of controller malfunction or boiler maintenance. In the automatic position the controller will maintain the desired setting to within one-hundredth (0.01) inch water column by varying the position of the draft damper.
5. The controller circuit shall interconnect with the combustion safeguard and limit-control circuits governing burner operation, to provide fixed damper opening for pre-purge and stable ignition, full modulation of damper during firing, and close damper after boiler shut down. However, burner shall shut down when switch is moved from automatic. The open damper switch shall provide means to fully open damper without interrupting firing.
6. The controller output shall drive a 150 inch-pound torque rotary actuator. Unit must be equipped with an adjustable “start position” switch. A purge position signal switch must be an integral part of the operator. The operator must be equipped with a mechanism permitting selection of any partially open setting of the damper for the purge position (minimum 20 percent). This feature must allow the full range of the damper opening to be utilized during the firing cycle, and also permit adjustment of the purge position to provide maximum opening of the damper without adverse effect on pilot operation.
7. All necessary linkage, including adjustable clevises, pipe adapters, and damper lever arms must be designed for the particular use of the equipment to be installed, to provide free, smooth and rigid operation, but eliminate unnecessary play and lost motion.

PART 3 - EXECUTION

3.1 INSPECTION:
A. Examine areas and conditions under which boilers are to be installed, and substrate which will support boilers. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF BURNERS:
A. General: Install burners in accordance with manufacturer's installation instructions, requirements State and local code and requirements of local Utility CompanyMaintain manufacturer's recommended clearances.
B. Gas Piping: Refer to Section 23 11 23 “Facility Natural Gas Piping”. Connect gas piping to boiler, full size of boiler gas train inlet, provide union with sufficient clearance for burner removal and service.
C. Electrical: Refer to Division 26.
3.3 CLOSEOUT PROCEDURES:

A. Owner’s Instructions: Provide services of manufacturer’s technical representative for one 8-hour
day to instruct Owner's personnel in operation and maintenance of boilers. Instruction to be
provided on site.

3.4 ADJUSTING AND CLEANING:

A. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces.

3.5 DEMONSTRATION:

A. Services: After testing and inspection is complete, provide the services of an authorized factory
service representative to perform start-up and operation demonstration service.

B. Start-up: Perform services in accordance with manufacturer's written start-up instructions. Test
controls and demonstrate compliance with requirements. Replace damaged or malfunctioning
controls and equipment.

C. Maintenance and Operation Training: As a part of the maintenance and operating instructions,
review data in operating and maintenance manual, including preventative maintenance schedule
and procedures, and procedures for obtaining repair parts and technical assistance. Demonstrate
all phases of operation including start-up and shut-down.

1. Schedule training with Owner, provide at least 7-day notice to Architect/Engineer.

D. Provide Combustion Test Record for each Boiler and each fuel which shall include a minimum of
the following information submitted following the test.

TIME:
DATE:

FUEL: BTU/LB
FIRING RATE: %
COMBUSTION EFFICIENCY: %
AMBIENT TEMPERATURE: °F.
STACK TEMPERATURE: °F
OXYGEN: %
CARBON MONOXIDE: PPM
CARBON DIOXIDE: %
COMBUSTIBLEGASES: %
STACK DRAFT (INCHES H₂O):
EXCESS AIR: %
OXIDES OF NITROGEN: PPM
SULFUR DIOXIDE: PPM
CARBON MONOXIDE ALARM: PPM
MANIFOLD PRESSURE: IN. WC
HWS TEMPERATURE °F
HWR TEMPERATURE °F
TEST PERFORMED BY:

END OF SECTION 23 52 00