

**SPECIFICATIONS**  
**FOR**  
**LAMAR COUNTY COURTHOUSE**  
**HVAC SYSTEM RENOVATION – PHASE 2**



**119 NORTH MAIN  
PARIS, TEXAS**

**Prepared by**

**Fanning, Fanning  
& Associates, inc.**

**CONSULTING ENGINEERS**

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**ISSUE FOR BIDS**

LAMAR COUNTY COURTHOUSE  
HVAC SYSTEM RENOVATION – PHASE 2  
119 North Main  
Paris, Texas

**DESIGN PROFESSIONAL RESPONSIBILITY**

The specification sections authenticated by my seal and signature are limited to the following:

**DIVISION 15: MECHANICAL**

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15000	General Provisions for Mechanical and Electrical
15300	Piping and Accessories
15350	Plumbing Systems
15400	Air Distribution
15500	Hangers and Supports
15550	Vibration Isolation
15600	Insulation
15710	Packaged Rooftop Units / Outdoor Air Handling Units
15800	Testing, Adjusting and Balancing Mechanical Systems
15900	Temperature Regulation

**DIVISION 16: ELECTRICAL**

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16010	Basic Electrical Requirements
16110	Raceways
16120	Wires and Cables
16130	Boxes
16140	Wiring Devices
16170	Grounding and Bonding
16195	Electrical Identification
16441	Safety Switches
16470	Panelboards



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**DRAWINGS**

M005	Mechanical - Demolition - Roof Plan
M100	Mechanical - New - Basement Floor Plan
M105	Mechanical - New - Roof Plan
M106	Mechanical Schedules
E100	Electrical - New - Basement Floor Plan
E101	Electrical - New - Roof Plan

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## SECTION 15000 - GENERAL PROVISIONS FOR MECHANICAL AND ELECTRICAL

### PART 1 - GENERAL

#### 1.1 SPECIAL NOTE

- A. The Architectural and Structural Plans and Specifications, including the supplements issued thereto, Information to Bidders, and other pertinent documents issued by the Architect, are a part of these specifications and the accompanying mechanical and electrical plans, and shall be complied with in every respect. All the above is included herewith, will be issued separately or is on file at the Architect's office, and shall be examined by all bidders. Failure to comply shall not relieve the Contractor of responsibility or be used as a basis for additional compensation due to omission of drawings. Where the Supplementary General Conditions conflict with the General Conditions, the Supplementary General Conditions shall govern.

#### 1.2 CHECKING DOCUMENTS

- A. The drawings and the specifications are numbered consecutively. The Contractor shall check the drawings and specifications thoroughly and shall notify the Architect of any discrepancies or omissions of sheets or pages. Upon notification, the Architect will promptly provide the Contractor with any missing portions of the drawings or specifications. No discrepancies or omissions of sheets or pages of the contract documents will relieve the Contractor of his duty to provide all work required by the complete contract documents.

#### 1.3 GENERAL

- A. In general, the lines and ducts to be installed by the various trades under these specifications shall be run as indicated, as specified herein, as required by particular conditions at the site, and as required to conform to the generally accepted standards as to complete the work in a neat and satisfactorily workable manner. The following is a general outline concerning the running of various lines and ducts and is to be excepted where the drawings or conditions at the building necessitate deviating from these standards.
- B. All piping, conduit and ductwork for the mechanical and electrical trades shall be concealed in chases in finished areas, except as indicated on the drawings. Horizontal lines run in areas that have ceilings shall be run concealed in those ceilings, unless otherwise specifically indicated or directed.
- C. Piping, ductwork, conduits and raceways may be run exposed in machinery and equipment spaces, where serving as connections to motors and equipment items in finished rooms where exposed connections are required, and elsewhere as indicated on the drawings or required.
- D. All conduits in any space where they are exposed shall run parallel with the building walls. They shall enter the concealed areas perpendicular with the walls, ceilings or floors. Fittings shall be used where necessary to comply with this requirement.
- E. The Contractor shall thoroughly acquaint himself with the details of the construction and finishes before submitting his bid as no allowances will be made because of the Contractor's unfamiliarity with these details. Place all inserts in masonry walls while they are under construction. All concealed lines shall be installed as required by the pace of the general construction to precede that general construction.

- F. The mechanical and electrical plans do not give exact details as to elevations of lines and ducts, exact locations, etc., and do not show all the offsets, control lines, pilot lines and other installation details. The Contractor shall carefully lay out his work at the site to conform to the architectural and structural conditions, to provide proper grading of lines, to avoid all obstruction, to conform to details of installation supplied by the manufacturers of the equipment to be installed, and thereby to provide an integrated, satisfactorily operating installation.
- G. The electrical plans show diagrammatically the locations of the various electrical outlets and apparatus and the method of circuiting and controlling them. Exact locations of these outlets and apparatus shall be determined by reference to the general plans and to all detail drawings, equipment drawings, roughing-in drawings, etc., by measurements at the building, and in cooperation with other sections, and in all cases shall be subject to the approval of the Architect. The Architect reserves the right to make any reasonable change in location of any outlet or apparatus before installation (within 10 feet of location shown on drawings) or after installation if an obvious conflict exists, without additional cost to the Owner.
- H. The mechanical plans do not give exact locations of outlets, fixtures, equipment items, etc. The exact location of each item shall be determined by reference to the general plans and to all detail drawings, equipment drawings, roughing-in drawings, etc., by measurements at the building, and in cooperation with other sections. Minor relocations necessitated by the conditions at the site or as directed by the Architect shall be made without any additional cost accruing to the Owner.
- I. The Contractor shall be responsible for the proper fitting of his material and apparatus into the space. Should the particular equipment which any bidder proposes to install require other space conditions than those indicated on the drawings, he shall arrange for such space with the Architect before submitting his bid. Should changes become necessary on account of failure to comply with this clause, the Contractor shall make such necessary changes at his (the Contractor's) own expense.
- J. The Contractor shall submit working scale drawings of all his apparatus and equipment which in any way varies from these specifications and plans, which shall be checked by the Architect before the work is started, and interferences with the structural conditions shall be corrected by the Contractor before the work proceeds.
- K. Order of precedence shall be observed in laying out the pipe, ductwork, material, and conduit in order to fit the material into the space above the ceiling and in the chases and walls. The following order shall govern:
1. Items affecting the visual appearance of the inside of the building such as lighting fixtures, diffusers, grilles, outlets, panelboards, etc. Coordinate all items to avoid conflicts at the site.
  2. Lines requiring grade to function such as sewers.
  3. Large ducts and pipes with critical clearances.
  4. Conduit, water lines, and other lines whose routing is not critical and whose function would not be impaired by bends and offsets.
- L. Piping, ducts, and conduits serving outlets on items of equipment shall be run in the most appropriate manner. Where the equipment has built-in chases, the lines shall be contained therein. Where the equipment is of the open type, the lines shall be run as close as possible to the underside of the top and in a neat and inconspicuous manner.
- M. Exceptions and inconsistencies in plans and specifications shall be brought to the Architect's attention before the contract is signed. Otherwise, the Contractor shall be responsible for any and

all changes and additions that may be necessary to accommodate his particular apparatus, material, or equipment.

- N. The Contractor shall distinctly understand that the work described herein and shown on the accompanying drawings shall result in a finished and working job, and any item required to accomplish this intent shall be included whether specifically mentioned or not.
- O. Each bidder shall examine the plans and specifications for the General Construction. If these documents show any item requiring work under Division 15 or 16 and that work is not indicated on the respective "M", "P" & "E" drawings, he shall notify the Architect in sufficient time to clarify before bidding. If no notification is received, the Contractor is assumed to require no clarification, and shall install the work as indicated on the General Plans in accordance with the specifications.

#### 1.4 DIMENSIONS

- A. Before ordering any material or doing any work, the Contractor shall verify all dimensions, including elevations, and shall be responsible for the correctness of the same. No extra charge or compensation will be allowed on account of differences between actual dimensions and measurements indicated on the drawings. Any difference which may be found shall be submitted to the Architect for consideration before proceeding with the work.

#### 1.5 INSPECTION OF SITE

- A. The accompanying plans do not indicate completely the existing mechanical and electrical installations. The bidders for the work under these sections of the specifications shall inspect the existing installations and thoroughly acquaint themselves with conditions to be met and the work to be accomplished in removing and modifying the existing work, and in installing the new work in the present building and underground serving to and from that structure. Failure to comply with this shall not constitute grounds for any additional payments in connection with removing or modifying any part of the existing installations and/or installing any new work.

#### 1.6 ELECTRICAL WIRING

- A. All electric wiring of every character, for power supply, for communications, etc. will be done under Division 16 of these specifications. The Contractor for each section shall erect all his motors in place ready for connections. The Contractor, under Division 16, shall mount all the starters and controls, furnishing the supporting structures and any required outlet boxes. The Temperature Control Contractor shall include in his bid and shall furnish all wiring required for control, including line (120v/1phase/60hz) voltage wiring and low voltage control wiring. All wiring shall be in conduit. Include extending line voltage electrical to a space in the nearest electrical panel (or as shown on the drawings) and providing breakers as required to terminate all power required to make temperature controls functional.
- B. Every electrical current consuming device furnished as a part of this project or furnished by the Owner and installed in this project, shall be completely wired up under Division 16, and is a part of this contract. Verification of exact location, method of connection, number and size of wires required, voltage requirements, and phase requirements is the responsibility of the Contractor under Division 16. If conflicts occur between the drawings and the actual requirements, actual requirements shall govern. The contractor shall coordinate the voltage of all motors and any associated variable frequency drives with the Division 16 contractor prior to ordering the devices.

- C. Where no temperature control scope is shown in the documents, it shall be the responsibility of the Division 16 contractor to provide wiring, conduit and switches for the manual control of equipment, unless specifically noted to the contrary on the drawings and specifications.

#### 1.7 MOTORS AND CONTROLS

- A. All motors furnished under any of the several sections of these specifications shall be of recognized manufacture, of adequate capacity for the loads involved and wound for the current characteristics shown on the electrical drawings. All motors shall conform to the standards of manufacture and performance of the National Electrical Manufacturers' Association as shown in their latest publications. They shall further be listed by Underwriters Laboratories.
- B. Unless otherwise noted, the Contractor under Division 15 shall furnish each motor with a starter and all controls of the types specified or required. These starters shall be of the totally enclosed type, of capacity rating within the required limits of the motors which they are to serve, shall be suitable for the motor current characteristics and shall provide solid state overload protection, providing protection against single-phase events. All starters shall be standard of manufacture and performance of the National Electrical Manufacturers' Association. They further shall be listed by Underwriters Laboratories. Provide overload protection in each phase wire.

#### 1.8 PROGRESS OF WORK

- A. The Contractor shall keep himself fully informed as to the progress of the work and do his work at the proper time without waiting for notification from the Architect or Owner.

#### 1.9 FACTORY STARTUP OF EQUIPMENT

- A. The Contractor shall provide factory startup or factory authorized startup for certain equipment furnished for this project. Equipment requiring factory startup shall include the following: DOAS and Controls systems. Contractor shall submit the manufacturer's startup checklist substantiating that the equipment has been started and is operating in accordance with the manufacturer's instructions. The startup shall be performed by a person in the direct employ of the manufacturer or by an authorized agent. If the startup is performed by an authorized agent, the startup report shall be accompanied by a letter from the manufacturer identifying the agent as one who is certified to perform factory startup on the equipment furnished. As a minimum, submit the startup checklist with any comments or deficiencies noted during startup. Submit the report with certification letter (as required) to the Commissioning Agent for inclusion in the commissioning documentation. If there is no Commissioning Agent for the project, submit the startup reports as a submittal package to the Architect.

#### 1.10 MANUFACTURER'S DIRECTIONS

- A. All manufactured articles shall be applied, installed and handled as recommended by the manufacturer. All items of equipment provided shall be piped in strict accordance with its manufacturer's written installation instructions. Note that details on the drawings may be for equipment that is ultimately not furnished for the project and is for bidding purposes. Exact configuration shall match manufacturer's installation instructions.

#### 1.11 MATERIALS AND WORKMANSHIP

- A. All materials shall be new unless otherwise specified and of the quality specified. Materials shall be free from defects. All materials of a type for which the Underwriters Laboratories, Inc. have

established a standard shall be listed by the Underwriters Laboratories, Inc. and shall bear their label.

- B. Wherever the make of material or apparatus required is not definitely specified, the Contractor shall submit a sample to the Architect before proceeding.
- C. The Architect reserves the right to call for samples of any item of material offered in substitution, together with a sample of the specified material, when, in the Architect's opinion, the quality of the material and/or the appearance is involved and it is deemed that an evaluation of the two materials may be better made by visual inspection. This shall be limited to lighting fixtures, wiring devices, plumbing brass, grilles, registers, ceiling outlets and similar items and shall not be applicable to major manufacturers' items of equipment.
- D. The Contractor shall be responsible for transportation of his materials to and on the job and shall be responsible for the storage and protection of these materials and work until the final acceptance of the job.
- E. The Contractor shall furnish all necessary scaffolding, tackle, tools and appurtenances of all kinds, and all labor required for the safe and expeditious execution of his contract.
- F. The workmanship shall in all respects be of the highest grade and all construction shall be done according to the best practice of the trade.

#### 1.12 SUBSTITUTION OF MATERIALS

- A. Where a definite material of a specific manufacturer is mentioned in these specifications, it has been done in order to establish a base for competitive bidding, and each bidder shall include in his bid sum the cost of the named materials or manufactured items.
- B. Where practical, in mentioning the name of a specific manufacturer, the specifications list alternate manufacturers whose products are acceptable. In each such case, the bidder shall list the equipment item and opposite it shall list the name of the manufacturer whose product he proposes to use. This list of manufacturers shall be submitted with his proposal and shall be a part thereof.
- C. It is recognized that acceptable materials are offered by manufacturers other than those named in the specifications. Each bidder may therefore submit, with his proposal, all requests for substitutions which he desires to make, together with the adjustment to be made in his bid sum in each case should the substitute be accepted. Requests for permission to make substitutions will not be considered subsequent to the opening of bids except in the case of an emergency which would result in delay of the project.
- D. The successful bidder shall be prepared to furnish complete descriptive literature and complete operation and performance data on all substitute materials. The Architect will investigate such requests for substitutions, consult with the Owner when necessary and render final decisions prior to the signing of the Contract.

#### 1.13 SHOP DRAWINGS

- A. Wherever shop drawings are called for in these specifications, they shall be furnished by the Contractor for the work involved after review by the Architect as to the make and type of material and in sufficient time so that no delay or changes will be caused. This is done in order to facilitate progress on the job and failure on the part of the Contractor to comply shall render him liable to

stand the expense of any and all delays, changes in construction, etc., occasioned by his failure to provide the necessary details. Also, if the Contractor fails to comply with this provision, the Architect reserves the right to go directly to the manufacturer he selects and secure any details he might deem necessary and should there be any charges in connection with this, they shall be borne by the Contractor.

- B. Shop drawings will be reviewed by the Architect for general compliance with the design concept of the project and general compliance with the information given in the contract documents. Review by the Architect and any action by the Architect in marking shop drawings is subject to the requirements of the entire contract documents. Contractor will be held responsible for quantities, dimensions which shall be confirmed and correlated at the job site, fabrication processes and techniques of construction, coordination of all trades and the satisfactory performance of his work.
- C. Shop drawings submitted shall not consist of manufacturers' catalogues or tear sheets therefrom that contain no indication of the exact item offered. Rather, the submission of individual items shall designate the exact item offered and shall clearly identify the item with the project.
- D. All shop drawings shall be submitted at one time where possible. If hard copy is submitted, it shall consist of a bound catalogue of all shop drawings under each section. Electronic submittals are preferred. Submit ONE .pdf file per specification section, named as follows: Jobname\_15XXX\_SpecSectionName.pdf. Include a cover letter from the contractor as the first sheet of the submittal, certifying that the submittal has been properly indexed and has been checked by the Contractor. Each item submitted shall include a cover letter by the material supplier, clearly indicating exact model numbers and details to be furnished for each item specified in the section.
- E. The omissions of any material from the shop drawings which has been shown on the contract drawings or specified, even though reviewed by the Architect, shall not relieve the Contractor from furnishing and erecting same.

#### 1.14 PROTECTION OF APPARATUS

- A. The Contractor shall at all times take such precautions as may be necessary to properly protect his new apparatus from damage. This shall include the erection of all required temporary shelters to adequately protect any apparatus stored in the open on the site, the cribbing of any apparatus above the floor of the construction, and the covering of apparatus in the incompleting building with tarpaulins or other protective covering. Failure on the part of the Contractor to comply with the above to the entire satisfaction of the Architect will be sufficient cause for the rejection of the pieces of apparatus in question.

#### 1.15 PERMITS, FEES, ETC.

- A. The Contractor under each section of these specifications shall arrange for a permit from the local authority. The Contractor shall arrange for all utility services, including sewer, water, gas and electric services as applicable. If any charges are made by any of the utility companies due to the work on this project, the Contractor shall pay these charges, including charges for metering, connection, street cutting, etc. The Contractor shall pay for any inspection fees or other fees and charges required by ordinance, law, codes and these specifications.



1.16 TESTING

- A. The Contractor under each division shall at his own expense perform the various tests as specified and required by the Architect and as required by the State and local authorities. The Contractor shall furnish all fuel and materials necessary for making tests.

1.17 LAWS, CODES AND ORDINANCES

- A. All work shall be executed in strict accordance with all local, state and national codes, ordinances and regulations governing the particular class of work involved, as interpreted by the inspecting authority. The Contractor shall be responsible for the final execution of the work under this heading to suit those requirements. Where these specifications and the accompanying drawings conflict with these requirements, the Contractor shall report the matter to the Architect, shall prepare any supplemental drawings required illustrating how the work may be installed so as to comply and, on approval, make the changes at no cost to the Owner. On completion of the various portions of the work the installation shall be tested by the constituted authorities, approved and, on completion of the work, the Contractor shall obtain and deliver to the Owner a final certificate of acceptance.

1.18 TERMINOLOGY

- A. Whenever the words "furnish", "provide", "furnish and install," "provide and install", and/or similar phrases occur, it is the intent that the materials and equipment described be furnished, installed and connected under this Division of the Specifications, complete for operation unless specifically noted to the contrary.
- B. Where a material is described in detail, listed by catalogue number or otherwise called for, it shall be the Contractor's responsibility to furnish and install the material.
- C. The use of the word "shall" convey a mandatory condition to the contract.
- D. "This section" always refers to the section in which the statement occurs.
- E. "The project" includes all work in progress during the construction period.
- F. In describing the various items of equipment, in general, each item will be described singularly, even though there may be a multiplicity of identical or similar items.

1.19 COOPERATION AND CLEANING UP

- A. The contractor for the work under each section of these specifications shall coordinate his work with the work described in all other sections of the specifications to the end that, as a whole, the job shall be a finished one of its kind, and shall carry on his work in such a manner that none of the work under any section of these specifications shall be handicapped, hindered or delayed at any time.
- B. At all times during the progress of the work, the Contractor shall keep the premises clean and free of unnecessary materials and debris. The Contractor shall, on direction at any time from the Architect, clear any designated areas or area of materials and debris. On completion of any portion of the work, the Contractor shall remove from the premises all tools and machinery and all debris occasioned by the work, leaving the premises free of all obstructions and hindrances.

## 1.20 COORDINATION OF TRADES

- A. The Contractor shall be responsible for resolving all coordination required between trades. For example, items furnished under Division 15 which require electrical connections shall be coordinated with Division 16 for:
  - 1. Voltage
  - 2. Phase
  - 3. Ampacity
  - 4. No. and size of wires
  - 5. Wiring diagrams
  - 6. Starter size, details and location
  - 7. Control devices and details
- B. Items furnished under various sections which require plumbing connections shall be coordinated for services, pressure, size and location of connections, type of fuel, clearances for service, auxiliary devices required, etc.
- C. Items requiring insulation shall be fully insulated and that insulation shall be checked against manufacturer's directions and job requirements for suitability, coverage, thickness and finish.
- D. Items installed in/on finished ceilings shall be coordinated with the ceiling construction. The Contractor under each section shall conform to the reflected ceiling plan and shall secure details and/or samples of the ceiling materials as necessary to insure compatibility. Any device not conforming to this requirement shall be replaced by the Contractor at his expense.
- E. All items specified under Divisions 15 and 16 shall be installed tight, plumb, level, square and symmetrically placed in relation to the work of other trades.

## 1.21 CUTTING AND PATCHING

- A. The Contractor for work specified under each section shall perform all structural and general construction modifications and cut all openings through either roof, walls, floors or ceilings required to install all work specified under that section or to repair any defects that appear up to the expiration of the guarantee. All of this cutting shall be done under the supervision of the Architect and the Contractor shall exercise due diligence to avoid cutting openings larger than required or in wrong locations. Verify the scope of this work at the site and in cooperation with all other trades before bidding.
- B. No cutting shall be done to any of the structural members that would tend to lessen their strength, unless specific permission is granted by the Architect to do such cutting.
- C. The Contractor for work under each section shall be responsible for the patching of all openings cut to install the work covered by that section and to repair the damage resulting from the failure of any part of the work installed hereunder.
- D. Before bidding, the Contractor shall review and coordinate the cutting and patching required under the respective section with all trades.
- E. In all spaces where new work under Division 15 and 16 is installed and no other alteration or refinishing work is shown or called for, existing floors, walls and ceilings shall be restored to match existing conditions. All cutting and patching shall be done by workmen skilled in the affected trade.

- F. Where openings are cut through masonry walls, the Contractor under each respective section shall provide and install lintels or other structural supports to protect the remaining masonry and adequate support shall be provided during the cutting operation to prevent any damage to the masonry occasioned by the operation. All structural members, supports, etc. shall be of the size, shape, and installed as directed by the Architect.

## 1.22 PAINTING

- A. Painting for Divisions 15 and 16 shall be as follows:

1. If the factory finish on any apparatus or equipment is marred, it shall be touched up and then given one coat of half-flat-half-enamel, followed by a coat of machinery enamel of a color to match the original. Paint factory primed surfaces.
2. Paint all exposed pipe, conduit, boxes, cabinets, hangers and supports, and miscellaneous metal.
3. Paint all exposed sheet metal.
4. Paint all insulated surfaces exposed to view, including piping, equipment, etc. Surfaces until a smooth, non-grainy surface is obtained.

- B. Generally, painting is required on all surfaces such that no exposed bare metal or insulation surface is visible.

## 1.23 SEALING

- A. The Contractor installing pipes, conduits, ducts, etc., shall seal all spaces between pipes and/or sleeves where they pierce walls, partitions or floors by packing fire resistant rope and fire-resistant cement. The packing shall effect a complete fire and/or air seal where pipes, conduits, ducts, etc., pierce walls, floors or partitions.

## 1.24 LARGE APPARATUS

- A. Any large piece of apparatus which is to be installed in any space in the building, and which is too large to permit access through windows, doorways or shafts, shall be brought to the job by the Contractor involved and placed in the space before the enclosing structure is completed.

## 1.25 ACCESS PANELS

- A. Wherever mechanical and/or electrical equipment is installed and where future access is required through either walls or ceilings and such cannot be obtained through the removable ceiling or through other means, the Contractor shall provide Milcor Style "M" access doors at least 12 inches by 12 inches in size or larger if required for access. Provide access doors for all fire dampers, smoke dampers, valves, etc.

## 1.26 SCHEDULE OF WORK

- A. Under no condition shall any work be done in the present building that would interfere with its natural use during its normal hours of occupancy, unless special permission is granted by the Owner. This is particularly applicable where new connections are to be made to present lines or items of equipment in that building or where present equipment items in that building are to be relocated or modified in any way. The Contractor shall include this scheduling requirement in his proposal as no additional compensation for overtime work will be granted.

#### 1.27 WORKING TIME

- A. All work required by these installations shall be done during normal working hours, except in such cases as are specifically excepted hereinbefore. The Owner reserves the right to direct, at his own discretion, that any other parts of the work be done at other than normal working hours; in which case the Contractor involved shall be reimbursed by an amount equal to the excess cost of such overtime labor above the value of the same at regular rates.

#### 1.28 RELOCATION OF EXISTING INSTALLATION

- A. There are portions of the existing plumbing system, heating, ventilating and air conditioning system and electrical System which shall remain in use to serve the finished building in conjunction with the indicated new installations. By actual examination at the site, each bidder shall determine those portions of the remaining present installations which must be relocated to avoid interferences with the installations of new work of his particular trade and that of all other trades. All such existing installations which interfere with new installations shall be relocated by the Contractor under the Division in which the existing material normally belongs, and in a manner as directed by the Architect. For example:
  - 1. Existing Plumbing piping, etc. shall be relocated under Division 15 where it interferes with the installation of new work.
  - 2. Where existing piping, ductwork, etc. interferes with the installation of new work, it shall be relocated under Division 15.
  - 3. Where existing conduit and electrical equipment interferes with the installation of new work, it shall be relocated under Division 16.
- B. Failure to become familiar with the extent of the relocation work involved shall not relieve the Contractor of responsibility and shall not be used as a basis for additional compensation.

#### 1.29 SALVAGE MATERIALS

- A. The Contractor shall remove existing equipment, piping, duct, grilles, conduit, wire, junction boxes, light fixtures and other items associated with the mechanical, plumbing and electrical systems where shown on the drawings. Where such items are exposed to view or uncovered by any cutting or removal of general construction and has no continuing function (as determined by the Architect), they shall be removed by the contractor under the section in which the item normally falls.
- B. Existing items (see above) where concealed in/above construction, which is not disturbed, abandon in place. Plug, cap, disconnect or otherwise render harmless all such items.
- C. All items or materials removed from the project shall be made available for the Owner's inspection. The Owner retains the option to claim any item or material. Contractor shall deliver any claimed item or material in good condition to the place designated by the Owner. All item not claimed become the property of the contractor and shall be removed from the site.

#### 1.30 INSTALLATION DRAWINGS

- A. It shall be incumbent upon the Contractor to prepare special drawings as called for elsewhere herein or as directed by the Architect to coordinate the work under each section, to illustrate changes in his work, to facilitate its concealment in finished spaces to avoid obstructions or to illustrate the adaptability of any item of equipment which he proposes to use.

- B. These drawings shall be used in the field for the actual installation of the work. Unless otherwise directed, they shall not be submitted for approval, but three copies shall be provided to the Architect for his information.

#### 1.31 ROUGH-IN AND MAKE FINAL CONNECTION FOR EQUIPMENT

- A. The shop drawings for all equipment are hereby made a part of these specifications. The Contractor under each section of the specifications shall rough-in for the exact item to be furnished on the job, whether in another section of the specifications or by the Owner. The Contractor shall refer to all drawings and other sections of the specifications for the scope of work involved for the new equipment, and by actual site examination determine the scope of the required equipment connections for the Owner furnished equipment.
- B. Should any of the equipment furnished require connections of a nature different from that shown on the drawings, report the matter to the Architect and finally connect as directed by the Architect.
- C. Should any shop drawings not be available for equipment furnished under other contracts or by the Owner, the Contractor under each section of these specifications shall bid the work as detailed on the drawings.
- D. Minor differences in the equipment furnished and that indicated on the drawings will not constitute ground for additional payment to the Contractor.

#### 1.32 MARKING OF PIPE

- A. The Contractor shall mark all accessible piping systems. The identification of a piping system shall be made by a positive identification of the material content of the system by lettered legend, giving the name of the content in full or abbreviated form. This mark shall be conspicuously placed at frequent intervals on straight runs, close to all valves, at changes of direction and where pipes pass through walls, floors or ceilings. Arrows shall be used to indicate direction of flow. Markers shall be painted on using stencils.
- B. Markers shall be placed on piping at each connection to an item of equipment, at each pump, and on each drop to an outlet. Markers shall be placed on each run of piping at intervals not exceeding 50 feet where exposed in a room and 25 feet when installed above removable ceilings, except that no exposed line shall enter a room without being identified therein. Marker on lines above removable ceilings shall be applied on the undersides of the lines and in other areas shall be applied to be most visible. Also supply directional flow indicators adjacent to identification markers.
- C. Size of Identification:

Outside Diameter	Size of Legend of Pipe or Covering Letters (" Height)
3/4 to 1-1/4	1/2
1-1/2 to 2	3/4
2-1/2 to 6	1-1/4

#### 1.33 IDENTIFICATION AND LABELING

- A. The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, valves, piping, etc.,

by marking them. All items of equipment such as fans, pumps, etc., shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same number as shown on the drawings. For example, pumps will be identified as P-1, P-2, P-3, etc.; exhaust fans will be EF-1, EF-2, etc.; AC Units will be AC-1, AC-2, etc.

- B. All items of mechanical and electrical equipment shall be identified by the attachment of engraved nameplates constructed from laminated phenolic plastic, at least 1/16" thick, 3-ply, with black surfaces and white core. Engraving shall be condensed gothic, at least 1/2" high, appropriately spaced. Nomenclature on the label shall include the name of the item, its mark number, area, space, or equipment served, and other pertinent information. Equipment to be labeled shall include but not be limited to the following:

1. Boilers
2. Chillers
3. Pumps
4. AC Units
5. Convertors
6. Air Conditioning Control Panels and Switches
7. Exhaust and Return Air Fans
8. Miscellaneous - similar and/or related items

#### 1.34 OPERATING INSTRUCTIONS

- A. The Contractor for each section of the work hereunder shall, in cooperation with the representatives of the manufacturers of the various equipment items, carefully instruct the Owner's representatives in the proper operation of each item of equipment and of each system. During the balancing and adjusting of systems, the Owner's representative shall be made familiar with all procedures.

#### 1.35 OPERATING MANUALS

- A. Prepare and submit 3 copies of the operating manuals bound in hard covers. Three weeks prior to completion of the work, the Architect will check the manuals and any additional material necessary to complete the manuals shall be furnished and inserted by the Contractor.
- B. Manuals shall contain the following data:
1. Catalogue data of all equipment.
  2. Shop drawings of all equipment.
  3. Temperature control drawings (reduced in size)
  4. Start-up instructions for major equipment.
  5. Trouble shooting procedures for major equipment.
  6. Wiring diagrams.
  7. Recommended maintenance schedule for equipment.
  8. Parts list for all items.
  9. Name and address of each vendor.

#### 1.36 GUARANTEE

- A. Unless a longer period is specified elsewhere, the contractor shall guarantee all workmanship and materials for a period of one year from date of final acceptance.

### 1.37 COMPLETION REQUIREMENTS

- A. Before acceptance and final payment, the Contractor under each Division of the specifications shall furnish:
1. Accurate "as built" drawings, shown in red ink on blue line prints furnished for that purpose all changes from the original plans made during installation of the work. Drawings shall be filed with the Architect when the work is completed.
  2. All manufacturers' guarantees.
  3. All operating manuals.
  4. Guarantees.
  5. Test and Balance Report.

### 1.38 CONTRACTOR'S RESPONSIBILITY FOR FINAL INSPECTION

- A. Before calling for the final inspection, the Contractor under each Division shall carefully inspect his work to be sure it is complete and according to plans and specifications.

## PART 2 – PRODUCTS

Not Used

## PART 3 – EXECUTION

Not Used

END OF SECTION 15000

## SECTION 15300 - PIPING AND ACCESSORIES

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. This section of the specifications pertains to all labor, materials, equipment and service necessary for and incidental to the piping and accessories as shown on the drawings and/or specified herein.

#### 1.4 INSPECTION

- A. All pipe, valves, fittings, and other accessories shall be inspected upon delivery and during the course of the work. Any defective materials found during field inspection or during hydrostatic and leakage tests shall be removed from the site of the work and replaced by the Contractor.

#### 1.5 PROTECTION DURING STORAGE

- A. The interior of all pipes, fittings, and other accessories shall be kept free from dirt and foreign matter at all times. Valves and fittings shall be drained and stored in a manner that will protect them from damage by freezing.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. All materials shall be manufactured or fabricated in the United States of America.
- B. Materials shall conform to the listed standards. Refer to specific sections for materials to be used under that section. The following tabulation is for reference only to identify the applicable standard.

PVC Soil Pipe and Fittings	ASTM D3034, Type PSM Max. SDR = 35
PVC Soil Fittings – Elastomeric	ASTM D3212
Copper Tubing	ASTM B88
Wrought Copper Solder Fittings	ANSI B16.22
Cast Bronze Solder Fittings	ANSI B16.18
Steel Pipe	ASTM A120, A53, A106
Butt Weld Fittings	ANSI B16.9
Socket Weld Fittings	ANSI B16.11
Steel Flanges	ANSI B16.5
Malleable Iron Threaded Fittings	ANSI B16.3



- C. Unions in Ferrous Lines: 150-pound malleable iron, screwed pattern, ground joint with brass to iron seat; equal to Crane.
- D. Insulating Fittings: Equal to Maloney.
- E. Unions in Copper or Brass Lines: 125 pound all brass, screwed pattern, ground joint, equal to Chase, Crane or Mueller.

## 2.2 VALVES

- A. General Service Valves: 3" and smaller, all bronze, screwed; 3-1/2" and larger, flanged, iron body, bronze trimmed, equal to the following Crane Nos:

Type	Fluid Pressure Below 125 PSIG	Fluid Pressure Above 125 PSIG
Gate 2" and smaller	428	424
Gate 2-1/2" and larger	465-1/2	7-1/2 E
Globe 2" and smaller	1	14-1/2 P
Globe 2-1/2" and larger	351	21E
Angle 2" and smaller	2	16-1/2 P
Angle 2-1/2" and larger	353	23E

- B. Where valves have discs, select the discs for the intended service using materials as recommended by the valve manufacturer. Provide extended stems for valves in insulated lines, so that the handle clears the insulation and jacket.
- C. Acceptable General Service Valve Manufacturers: Stockham, Jenkins, OIC, Walworth, Hammond.
- D. Gas Valves: Iron body, lubricated plug valves equal to Nordstrom Fig. 143 in sizes 2-1/2" and larger. Valves 2" and smaller equal to Crane No. 270 or Lee 10685 iron body flat-head threaded gas stop.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF PIPING SYSTEMS

- A. Install runs of piping essentially as indicated on the drawings and/or as required. The location, direction and size of the various lines are indicated on the drawings.
- B. Make up all systems straight and true and properly graded for correct flow of contained materials and to provide drainage. Cut pipes accurately to measurements established at the building and work into place without forcing or springing. Except as required for specified grading, run all piping above ground parallel with the lines of the building.
- C. Make all changes in pipe sizes with reducing fittings. Use no long screws or bushings.

- D. Install and support piping systems with loops, bends, expansion joints and/or flexible connectors as required for flexibility, to accommodate expansion and contraction of piping due to temperature changes in the contained fluids and in the surrounding space, and to minimize the transmission of vibration to the building structure.
- E. Provide unions in the lines assembled with screwed and soldered fittings, at points of connection to equipment, and elsewhere as indicated or required to permit proper connections to be made, or to permit valves, equipment items, etc. to be removed. Provide unions also in welded lines at connections to equipment where flanges are not provided. Provide insulating unions where ferrous material joins non-ferrous material.
- F. In piping systems assembled by welding, use factory-fabricated welding fittings of the same material and the same schedule or weight as the piping in which they are installed, except that branches or take-offs of sizes not exceeding 2/3 of the nominal diameter of the mains may be made with Bonney Weldolets or Threadolets. Mitering of pipe to form elbows, notching of straight runs to form tees, and any similar construction will not be permitted.
- G. In general, use listed materials in fabricating the various piping systems. The method of assembly may be varied only to meet special conditions where it is impossible to comply with the specified method of joining piping. Where special classes of piping are involved and are not listed, request exact instructions as to the class of material involved and the method of fabricating it before ordering materials.

### 3.2 FLASHING

- A. Flash around all pipes passing through the roof with sheet lead not less than 4 lbs. per square foot, built a minimum of 8" in all directions from the outside of the pipe into the waterproofing. Flashing shall be run up the pipe and turned over into the pipe cavity. Flashing at roof drains shall be 36" square.
- B. Pitch Pans: Small lines thru the roof shall be installed thru pitch pans. Pans shall be 18-gage galvanized, welded, 3" deep, 8" X 8" or larger, packed with lead wool and filled with pitch.

### 3.3 ESCUTCHEONS, CEILING PLATES

- A. Except as otherwise noted provide and install concealed hinge, chrome plated escutcheons or ceiling plates with spring catches around each pipe passing through any wall, floor, or ceiling in any space, except in underfloor and attic spaces. Plates shall be sized to fit snugly against the outside of the pipe, or against the outside of the insulation on lines which are insulated.
- B. No floor plates will be required around the iron pipe sleeves on exterior walls.

### 3.4 INTERIOR TRENCHING

- A. Trenches for underfloor lines inside the building shall be properly excavated, following in general the procedures set out for exterior lines. Where floors are to be poured over these lines, they shall be backfilled, tamped, and settled with water.
- B. Where necessary to cut floors for installation of underfloor lines, the floor shall be saw cut and patched back to a flush and level condition.

- C. All surplus materials removed in these trenching operations shall be disposed of as directed by the Architect.

### 3.5 PROTECTION OF UNDERGROUND PIPING

- A. Underground steel piping shall be cleaned and primed with Humble "Rust-Ban" and wrapped with a double thickness of 3M Scotch "51" vinyl tape over pipe and fittings.

### 3.6 FABRICATION OF PIPE JOINTS

- A. Copper Tubing: Cut tubing square and deburr. Clean insides of fittings and outsides of tubing with sand cloth before assembly. Exercise care to prevent annealing of fittings and hard drawn tubing. Make all joints with solid string or wire solder, using non-corrosive paste flux of the proper type for each application. No cored solder will be permitted. Use 95-5 solder (95% tin, 5% antimony) or Silvacite 100 solder (95.5% tin, 4% copper, .5% silver composition) for all copper tubing. Under no circumstances will solder with any lead content be permitted on the jobsite. Where flanges are shown or are required for connection to equipment, they shall be 150 psi flanges.
- B. Welded Joints: Make all welded joints by the metallic arc process. Use base material conforming to ANSI B31.1 for welded pipe ASTM A106 and ASTM A53. Use filler material conforming to ASTM A233 and in accordance with ANSI B31.1. Machine the ends of the material to be joined or gas cut. Make the cut smooth in order that good fit can be made, and a full penetration weld made. Use direct current for welding with the electrode positive. Limit the depth of deposit to 1/8" per pass. Remove all slag or flux remaining on any bead of welding before laying down the next successive bead of welding. Remove any cracks or blow holes that appear on the surface of any bead of welding by chipping or grinding before depositing the next successive bead of welding.
- C. Mechanical Couplings: Mechanical couplings and fittings shall be used to connect mechanical equipment and piping systems where specified. Rigid couplings shall have angle-pad design equal to Victaulic Style 07, Zero-Flexible. Couplings shall be equal to Victaulic Style 77 where system flexibility is desired. Couplings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12 or malleable iron conforming to ASTM A-47, Grade 32510. Gaskets shall be Grade "E" EPDM compound conforming to ASTM D-2000 designation 2CA615A25B24F17Z. Coupling bolts shall be Zinc plated (ASTM-B-633) heat-treated carbon steel track head conforming to physical properties of ASTM A-183. Unless specifically designated otherwise on the drawings, all couplings shall be flexible type at pump connections and in Mechanical Rooms.
- D. Pipe Fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, or malleable iron conforming to ASTM A-47, Grade 32510. Where malleable fitting pattern is not available, fittings fabricated from Schedule 40 steel pipe or standard wall seamless weld fittings with grooved ends may be used.
- E. Before assembly of couplings, lightly coat gasket with lubricant to facilitate installation.
- F. Pipe grooving shall be in accordance with the manufacturer's specifications contained in the latest published literature.
- G. Flanged Joints: Flanged joints shall be made using bolts and gaskets as specified. Faces of the flanges shall be cleaned of all dirt, rust or other foreign matter. The pipe, valve, or fitting shall be properly aligned and free to move while bolting, and the bolts shall be gradually tightened at a uniform rate around the entire flange. No strain shall be put on the flanges in making up the joint.

H. Solvent Weld Plastic Joints: Solvent welded according to manufacturer's instructions.

I. Testing:

1. The Contractor shall have a minimum of 10 percent of all welds made by each welder examined and inspected by radiography. If a faulty weld is discovered, the Contractor shall perform radiographic inspection on all welds made by that welder. Any faulty welds shall be repaired and reinspected at the Contractor's expense.
2. The system shall be hydrostatically tested at 1.5 times the design pressure, as specified in Chapter VI ASME Code B31.1-1986 for Power Piping, and carefully checked for leaks. After leaks are repaired, retest system; repeat repair and test until proved tight. Equipment shall be isolated from hydrostatic testing of piping.
3. Welds which cannot be hydrostatically tested, e.g., branch connections made to existing piping, shall be radiographed per Chapter VI, ASME Code B31.1-1986 at Contractor's expense. The Owner at his option may allow visual inspection of these welds in lieu of radiographs.

### 3.7 REVISIONS AND RELOCATION OF EXISTING SYSTEMS

- A. Where conflicts occur between the new work and the existing piping systems which cannot be resolved, the Contractor shall relocate the existing piping system. Relocated positions of piping shall be tested for new work. All piping systems shall be free from leaks.

### 3.8 REPAIR OF LEAKS

- A. All leaks in piping systems shall be corrected as follows:

1. Repair leaks in solder joints by remaking the joint; no soldering or brazing over existing joints will be permitted.
2. Repair leaks in screwed joints by tightening the joint; remake the joint if the tightening fails to stop the leak.
3. Leaks in caulked joints may be stopped by additional caulking of the joint; but if that fails, remake the joint.
4. Repair leaks in welded joints by removing the defective weld completely through the base metal and grind smooth. Re-weld, accomplishing 100% penetration of the base metal. The repair weld should in no case be less than 4" in length.

- B. When any defect is repaired, retest that section of the system.

### 3.9 HANDLING OF MATERIAL

- A. Hauling: All materials furnished by the Contractor shall be delivered and distributed at the site by the Contractor.
- B. Loading and Unloading: Pipe, fittings, valves, and accessories shall be loaded or unloaded by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances shall such materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground. Each piece shall be unloaded opposite or near the place where it is to be installed. No material shall be unloaded where it will block any road, drive, building entrance, or walkway or where it will be a hazard to safe vehicular or pedestrian traffic.

- C. Care of Pipe Coating and Lining: Pipe shall be so handled that the coating and lining shall not be damaged. If, however, any part of the coating or lining is damaged, the repair shall be made by the Contractor at his expense. If satisfactory repair cannot be made, the Contractor shall replace the damaged pipe.

### 3.10 ALIGNMENT AND GRADES

- A. General: All pipe shall be laid and maintained to the required lines and grades with fittings, valves, at the required locations; spigots centered in bells; and all valve stems plumb. All pipes shall be installed straight and true to line.
- B. Deviations Occasioned by Other Structures: Whenever obstructions not shown on the plans are encountered during the progress of the work, the lines and/or grades shall be adjusted so to not interfere with existing obstructions.

END OF SECTION 15300

## SECTION 15350 - PLUMBING SYSTEMS

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. This section of the specifications requires the furnishing and installation of all equipment, labor, materials, transportation, tools and appliances and in performing all operations in connection with the installation of the plumbing systems.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS: Refer to Section "Piping and Accessories".

- A. Gas Lines: Schedule 40 black steel with 150 lbs. banded malleable iron fittings.
- B. Gas Lines: At Contractor's option NIBCO Bench PressG or Viega MegaPressG steel fittings may be used: Fittings shall conform to ANSI LC-4/CSA 6.32. HNBR elastomeric sealing elements. All connections shall bear full insertion marks on the tubing. Press Connect fitting shall have Leak Detection as standard feature to detect unpressed fittings during the testing process. There shall be no mixing of manufacturers. The manufacturer's installation instructions shall be strictly adhered to. Special attention shall be given to the required two step pressure test. Initial test for unpressed fitting detection per manufacturer's installation manual. Then full pressure test to 1.5 times design pressure. Installers shall be credentialed by manufacturer. Approved manufacturers: NIBCO, Viega.
- C. Drain Lines: PVC-DWV Plastic pipe and fittings conforming to ASTM D-2665-68, assembled with solvent cement conforming to ASTM D-2564-67. Smaller lines may be Schedule 40 PVC pipe and fittings.
- D. Miscellaneous Lines: Such as pilot lines, bleed lines, control and sampling lines, equalizer lines, drains from air vents and relief vents, etc. shall be fabricated of the materials used in the systems to which they are connected.

### PART 3 - EXECUTION

#### 3.1 INSTALLATION OF PIPING SYSTEMS

- A. Refer to PIPING AND ACCESSORIES for requirements for installing pipes. In addition, the following specifications shall apply.

1. Drain Lines and Sanitary Waste: Grade down toward the sewer connection at a uniform slope of 1/4" per foot to serve individual fixtures or not less than 1/8" per foot to serve multiple stacks or outlets. Slope shall be greater where possible and shall never be less than required to produce a flow velocity of 2 feet per second.
2. Vents: Grade up to the vent thru the roof. Terminate not less than 10" above the roof.
3. Gas Lines: All gas piping shall run exposed unless specifically detailed otherwise on the drawings, with special venting provisions.
4. A gas "drip pocket" or "dirt leg" shall consist of a nipple and screwed cap on the bottom of the riser and shall be installed at connections to equipment, at the low point of the system and at the natural gas line entrance to the building (with the "gas cock" shut off valve). Install as required by the International Fuel Gas Code.
5. Provide a gas cock, union and gas pressure regulator at each connection to a gas consuming appliance.
6. All gas piping on the roof shall be supported on Miro Pillow Block pipe stands, Model 02 for 2" and below, Model 24-R for piping 2" to 4" and Model 48-R for 5" and above. Pans shall be mopped to roof. Pipes shall be strapped to supports with galvanized strap.
7. Identification: For other than black steel pipe, exposed gas piping shall be identified by a yellow label marked "Gas" in black letters. The marking shall be spaced at intervals not exceeding 5 feet (1524 mm). The marking shall not be required on pipe located in the same room as the appliances served. All tubing carrying medium-pressure gas shall be marked with a label at the beginning and end of each tubing section.

### 3.2 TESTING

- A. Test all pipes before they are concealed in furrings or chases, insulated, painted, or otherwise covered up or rendered inaccessible. Accomplish testing by sections of lines or systems, as required by conditions during construction. Clean all piping and equipment before testing.
- B. Gas Lines: Test with 50 psig air pressure for 24 hours with no pressure drop (except for temperature correction). If any drop occurs, soap test all joints, correct leaks and retest.

END OF SECTION 15350

## SECTION 15400 - AIR DISTRIBUTION

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. This section of the specifications comprises the furnishing of all labor, materials, transportation, tools and appliances and in performing all operations in connection with the installation of apparatus casing, ductwork, plenums, linings, air distribution devices, dampers and control devices, relief air vents, curbs and other materials and accessories as described herein and/or as shown on the accompanying drawings, or reasonably implied therefrom.
- B. In addition, connect all air conditioning units, automatic dampers, filters and all other materials and install (and/or cooperate in the installation with other trades) those various items of equipment and materials.

### PART 2 – PRODUCTS

#### 2.1 LOW PRESSURE DUCTWORK

- A. Except as otherwise specified herein, in other sections of the specifications, and/or noted on the drawings, low-pressure ducts shall be constructed of galvanized steel sheets in accordance with the recommended construction for low pressure ducts insofar as gauges of metal to be used, bracing of joints and joint construction as established in the latest edition of the ASHRAE HANDBOOK.
- B. Duct construction details shall conform to "HVAC Duct Construction Standards", 3rd Edition, (2015) published by the Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA). Refer to the fan schedules (TSP) for system pressures. Construction shall be suitable for actual duct system pressures.
- C. Make square elbows where shown or required, with double thickness factory-fabricated turning vanes. Make all other changes in direction with rounded elbows having a centerline radius equal to 1-1/2 times the width of the duct in the plane of the bend.
- D. Make transformations in duct shape or dimension with gradual slopes on all sides. Make increases in dimensions in the direction of airflow, with a maximum slope of 1" in 7" on any side. Make decreases in dimensions in the direction of air flow preferably with a slope of 1" in 7" on any side, but with a maximum slope of 1" in 4" where conditions necessitate.
- E. Ducts shall be routed in conjunction with pipes, electrical conduits, ceiling hangers, etc. so as to avoid interferences insofar as possible. Where duct penetrations are unavoidable, provide



streamline shaped sleeves around such material penetrations, made airtight at duct surfaces, except that such sleeves are not required at tie rods. Where obstructions are of a size to exceed 10% of the duct area, the duct shall be transformed to maintain the same duct area.

## 2.2 DUCT CONSTRUCTION TEST

- A. A trial leak test, as specified herein, shall be made after installation of the first section of each type of ductwork to demonstrate adequacy of the construction details. All testing shall be done in the presence of the Architect.
- B. Each test section shall incorporate at least five transverse joints and all typical fittings.
- C. Drawings showing all construction details of test sections, test procedures and instrumentation, and test results shall be submitted for record purposes. No additional ductwork shall be installed until the trial test installation described above has been approved.
- D. Low pressure duct shall be tested at 3" w.c. Construction of low-pressure systems shall be inherently airtight, and leakage shall be of a sufficiently low magnitude as to be inaudible in quiet ambient and not detectable by sense of feel.

## 2.3 DUCT LINER

- A. Note that internal sizes are shown on the drawings.
- B. All sheet metal supply, return, and fresh air duct shall be lined.
- C. Conditioned Spaces:
  - 1. The listed ducts shall be lined to a thickness of 1" with Johns-Manville "Permacote Linacoustic" mat faced duct liner, or equal duct liner coated with immobilized antimicrobial impregnated acrylic surface coating on one side.
  - 2. Duct liner shall have an average thermal conductivity of .25 btu-in./sq. ft.-degree F. at a mean temperature of 75°F.
- D. Unconditioned Spaces:
  - 1. The listed ducts shall be lined to a thickness of 1-1/2" with Johns-Manville "Permacote Linacoustic" mat faced duct liner, or equal duct liner coated with immobilized antimicrobial impregnated acrylic surface coating on one side.
  - 2. Duct liner shall have an average thermal conductivity of .20 btu-in./sq. ft.-degree F. at a mean temperature of 75°F.
  - 3. Duct liner shall comply with ASTM C1071 with an NRC not less than 0.70 as tested per ASTM C423.
  - 4. The duct liner shall be applied in accordance with the manufacturer's recommendations with the coated side away from the metal, using weld pins or adhesive Tuffbond and adhesive type metal clips, Gemco, or equal, of the type which do not protrude through the duct. The size of the ducts indicated are actual internal sizes and the sheet metal sizes shall be 2" greater in both dimensions to accommodate the lining. No voids are permitted.
  - 5. Use 100% adhesive coverage and clips at the rate as specified by SMACNA.

## 2.4 DUCT SEALER

- A. All supply air ductwork from the air unit to the terminal units shall be sealed to provide airtight construction. Metal surfaces to be joined shall be clean, dry and free of dirt or grease. Apply a heavy coat of Foster 32-19, Childers CP-146 or Kingco Seal-Rite 18-120 water based, non fibrated duct sealant to the interior metal surface of the slip joint, then interlock into place metal duct sections. Apply a heavy coat of duct sealant to the exterior metal surface duct joint, making sure any voids are filled to secure a continuous air pressure sealant.
- B. Allow sealant to dry a minimum of 48 hours before pressurizing system.

## 2.5 OUTDOOR DUCTWORK - THERMADUCT

- A. The panel shall be manufactured of CFC-free Kingspan Kooltherm closed cell rigid thermoset resin thermally bonded on both sides to a factory applied .001" (25 micron) aluminum foil facing reinforced with a fiberglass scrim. An added UV stable, 1000-micron high impact resistant titanium infused vinyl is factory bonded to the outer surfaces to provide a zero permeability watertight barrier.
- B. The thermal conductivity shall be no greater than 0.13BTU • in/Hr •ft<sup>2</sup>•°F (.018W/m•°C), the thermal conductivity shall be no greater than 0.13BTU • in/Hr •ft<sup>2</sup>•°F (.018W/m•°C)
- C. The density of the Kooltherm foam shall not be less than 3.5 pcf (56 Kg/m<sup>3</sup>) with a minimum compressive strength of 28 psi (.2 MPa).
- D. The standard panel is (30 mm) thickness panel with R-8.1 (1.5 RSI) shall be utilized unless indicated otherwise on the print.
  - 1. Maximum Temperature: Continuous rating of 185°F (70°C) inside ducts or ambient temperature surrounding ducts.
  - 2. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg F at 75°F mean temperature.
  - 3. Permeability: 0.00 perms maximum when tested according to ASTM E 96/E 96M, Procedure A.
  - 4. Antimicrobial Agent: Additive for antimicrobial shall not be used but instead, raw product must pass UL bacteria growth testing.
  - 5. Noise-Reduction Coefficient: 0.05 minimum when tested according to ASTM C 423, Mounting A.
  - 6. Required Markings: All interior duct liner shall bear UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for internal closure materials.
  - 7. All insulation materials shall be closed cell with a closed cell content of >90%.
  - 8. R-value:
    - a. 1-3/16" (30 mm) Thick Panel: 8.1 R
    - b. 1-3/4" (45 mm) Thick Panel: 12 R
    - c. 2-1/16" Double wall (52 mm): 14.1 R
    - d. 2-3/8" Double wall (60 mm) Thick Panel: 16.2 R
    - e. 3" Double wall (75 mm) Thick Panel: 20.1 R
    - f. 3.5" Double wall (90 mm) Thick Panel 24 R
- E. Closure Materials:
  - 1. V-Groove Adhesive: Silicone (interior only).

2. UV stable 1000-micron high impact resistant titanium infused vinyl (exterior).
  - a. Factory manufactured seamless corners for zero perms.
  - b. Cohesive bonded over-lap at corner seam covers for zero perms.
  - c. Water resistant titanium infused welded vinyl seams.
  - d. Mold and mildew resistant.
3. Polymeric Sealing System:
  - a. Structural Membrane: Aluminum scrim with woven glass fiber with a laminated UV stable vinyl jacket.
  - b. Minimum Seam Cover Width: 2-7/8" (75 mm)
  - c. Sealant: Low VOC.
  - d. Color: Standard White (other light reflective colors available).
  - e. Water resistant.
  - f. Mold and mildew resistant.
4. Duct Connectors:
  - a. Factory manufactured cohesive bonded strips (low pressure only).
  - b. Factory manufactured all aluminum grip flange.
    - Grip flange
    - F-flange
    - H-flange
    - U-flange
  - c. Factory manufactured galvanized 4-bolt flange.
- F. Outdoor Cladding: Thermaduct outdoor Installations: Duct segments shall incorporate UV stable 1000-micron high impact resistant titanium infused vinyl which is introduced during the manufacturing process.
- G. Flange Coverings: Flanges are field sealed airtight before flange covers are installed. Flange covering consists of the following:
  1. Foam tape insulation with molded 1000 micron covers.
  2. Air gap (heating only application) with molded 1000 micron covers.
- H. Weight: Thermaduct shall provide low weight stresses on the building framing and support members. Assembled Thermaduct shall have a weight of 0.86 lbs. per square foot to maximum weight of 2.7 lbs. per square foot (depending on R-value). Hangers and tie-downs are to be detailed on the manufacturer's installing contractors detail drawings prior to installation but not exceeding 13' for duct girth <84" and 8' for duct girth >85" between hangers and designed to carry the weight and wind load of the ductwork.
- I. Shop Fabrication:
  1. Certification: Ducts shall be detailed and fully factory manufactured by an authorized Thermaduct, LLC facility system. All fabrication labor will be certified "yellow label" building trade professionals, compliant to SMWIA and SMACNA labor guidelines (work preservation observed).

2. Fabrication:

- a. Fabricated joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to manufacturer's written and detailed instructions.
- b. Fabricated 90-degree mitered elbows to include turning vanes.
- c. Fabricated duct segments in accordance with manufacturer's written details.
- d. Duct Fittings shall include 6 inches of connecting material, as measured, from last bend line to the end of the duct. Connections on machine manufactured duct may be 4 inches.
- e. Fabricated duct segments utilizing v-groove method of fabrication. Factory welded or cohesively bonded seams will apply to fully manufactured ductwork and fittings. Internal seams will be supplied with an unbroken layer of low VOC silicone or bonding (for paint shop applications). Each duct segment will be factory supplied with either aluminum grip pro-file or pre-insulated duct connectors in accordance with manufacturer's detailed submittal guide. Applied duct reinforcement to protect against side deformation from both positive and negative pressure per manufacturer's design guide based on specified ductwork size and system pressure.
- f. Designed and fabricated duct segments and fittings will be in accordance with "SMACNA Duct Construction Standards" latest edition.
- g. Both positive and negative ductwork and fittings shall be constructed to incorporate a UL Listed as a Class 1 air duct to Standard for Safety UL 181 liner with an exterior clad for permanent protection against water intrusion.
- h. Duct shall be constructed to exceed requirements for snow and wind loads.

J. Duct Installation:

1. Duct segments shall be installed by competent HVAC installers.
2. Install ducts and fittings to comply with manufacturer's installation instructions as follows:
  - a. Install ducts with fewest possible joints.
  - b. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
  - c. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
  - d. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."
  - e. Use prescribed duct support spacing as described in this specification and manufacturer's recommendations.
3. Air Leakage: Duct air leakage rates to be in compliance with "SMACNA HVAC Duct Construction Standards" latest version per applicable leakage class based on pressure.

K. Hanger and Support Installation:

1. Contractor to ensure that the ductwork system is properly and adequately supported.
  - a. Ensure that the chosen method is compatible with the specific ductwork system requirements per ThermaDuct installation detail drawings. Pre-installation should be provided prior to work commencement by installing contractor for approval.

- b. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
  - 2. Supports on straight runs of ductwork shall be positioned at centers not exceeding 13 feet (3.96 m) for duct sections when fabricated in 13-foot (3.96 m) lengths with duct girth less than 84". Larger duct sizes and short segments with duct girth greater than 84" are to be supported at 8-foot centers or less, in accordance with the Thermaduct installation details provided prior to work commencement.
  - 3. Ductwork shall be supported at changes of direction, at branch duct connections, tee fittings, parallel under turning vanes and all duct accessories such as dampers, etc.
  - 4. The load of such accessories to the ductwork shall be neutralized by the accessory support.
- L. Field Quality Control:
- 1. Inspection: Arrange for manufacturer's representative to inspect completed installation and provide written report that installation complies with manufacturer's written instructions.
    - a. Remove and replace duct system where inspection indicates that it does not comply with specified requirements.
  - 2. Perform additional testing and inspecting, at the Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
- M. Duct Schedule:
- 1. Outdoor Ducts and Fittings:
    - a. Thermaduct Rectangular Ducts and Fittings:  
Minimum Panel Thickness: 30 mm  
Cladding: minimum 1000 micron

## 2.6 OUTDOOR DUCTWORK – POLYGUARD ALUMAGUARD

- A. At the contractor's option, utilize rigid insulation with Polyguard Alumaguard as specified below.
- 1. Insulation Materials:
    - a. Comply with requirements in "Outdoor, Field-Applied Jacket Installation", and "Outdoor, Field-Applied Jacket Schedule" articles for application of insulating materials.
    - b. Products shall not contain asbestos, lead, mercury, or mercury compounds.
    - c. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
    - d. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
    - e. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
    - f. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - a) CertainTeed Corporation.
  - b) Johns Manville; a Berkshire Hathaway company.
  - c) Knauf Insulation.
  - d) Manson Insulation Inc.
  - e) Owens Corning.
  
- g. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a) CertainTeed Corporation.
    - b) Johns Manville; a Berkshire Hathaway company.
    - c) Knauf Insulation.
    - d) Manson Insulation Inc.
    - e) Owens Corning.
  
- h. Foam Insulation Board: Closed Cell, Isocyanurate, Extruded Polystyrene, Phenolic, Expanded Polystyrene. Minimum density 1.6 lb/cu. ft. (25.6 kg/cu. m); minimum compressive strength, 20-psi (137.9-kPa); either faced or unfaced.
  - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a) Dow Chemical Company (The).
    - b) Owens Corning.
    - c) <Insert manufacturer's name>.

2. Adhesives:

- a. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
  - 1) Adhesives shall have a VOC content of [50] <Insert value> g/L or less.
  - 2) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
  
- b. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

- 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    - a) Childers Brand; H. B. Fuller Construction Products.
    - b) Eagle Bridges - Marathon Industries.
    - c) Foster Brand; H. B. Fuller Construction Products.
    - d) Mon-Eco Industries, Inc.
    - e) <Insert manufacturer's name>.
  - 2) Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3) Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Self-Adhesive, Field-Applied, Outdoor Jackets:
- a. Basis-of-Design Product: Subject to compliance with requirements, provide Polyguard Products, Inc.; Alumaguard, Alumaguard All-Weather, Alumaguard Lite, or comparable product by one of the following:
    - 1) 3M.
    - 2) MFM Building Products Corp.
  - b. General Requirements for Self-Adhesive Outdoor Jacket: Laminated vapor barrier and waterproofing membrane with perm rating of 0.00 perm (0.00 metric perm), when tested according to ASTM E 96/E 96M, for installation over either fiberglass or foam board insulation located above ground outdoors; consists of a foil polymer laminated film with a coating of rubberized bituminous compound or acrylic adhesive that allows membrane to self-adhere to the substrate.
  - c. Alumaguard: Composite membrane consisting of a multi-ply embossed UV resistant aluminum foil/polymer laminate to which is applied a layer of rubberized asphalt.
    - 1) Alumaguard Membrane Thickness: 56-mils (1.42-mm).
    - 2) Alumaguard Cool Wrap Membrane Thickness: 59-mils (1.50-mm).
      - a) Solar Reflectance, CRRC Initial Rating: 0.86.
      - b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
      - c) Thermal Emittance, CRRC Initial Rating: 0.82.
      - d) Thermal Emittance, CRRC 3-Year Rating: 0.86.
  - d. Alumaguard Lite: Multi-ply aluminum foil/polymer composite film coated with a low-temperature acrylic adhesive.
    - 1) Smooth Silver Thickness: 7-mils (0.18-mm).
    - 2) Stucco Embossed Silver Thickness: 9-mils (0.23-mm).
    - 3) White Matte Cool Wrap Finish Thickness: 9-mils (0.23-mm).
      - a) Solar Reflectance, CRRC Initial Rating: 0.86.
      - b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
      - c) Thermal Emittance, CRRC Initial Rating: 0.82.

- d) Thermal Emittance, CRRC 3-Year Rating: 0.86.
  - 4) Alumaguard Lite White Thickness: 9-mils (0.23-mm).
- e. Alumaguard All-Weather: Hybrid product combining the UV-resistant aluminum foil/polymer laminate and rubberized asphalt used in the Alumaguard product, with a metalized film coated with low temperature acrylic adhesive.
  - 1) Alumaguard All-Weather Membrane Thickness: 35-mil (0.89-mm).
  - 2) Alumaguard All-Weather with Cool Wrap Coating Thickness: 38-mils (0.96-mm).
    - a) Solar Reflectance, CRRC Initial Rating: 0.86.
    - b) Solar Reflectance, CRRC 3-Year Rating: 0.77.
    - c) Thermal Emittance, CRRC Initial Rating: 0.82.
    - d) Thermal Emittance, CRRC 3-Year Rating: 0.86.
- 4. Examination: Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
  - a. Verify that systems and equipment to be insulated have been tested and are free of defects.
  - b. Verify that surfaces to be insulated are clean and dry.
  - c. Proceed with installation only after unsatisfactory conditions have been corrected.
- 5. General Installation: The contractor shall verify and obtain the latest installation instructions from the manufacturer prior to any work being done.
- 6. Outdoor, Field-Applied Jacket Installation:
  - a. Seal ducts in accordance with SMACNA HVAC Duct Construction Standards Metal and Flexible - Second Edition (1995) Seal Class A (or latest version of SMACNA) prior to installation of insulation and the outdoor, field-applied jacket. Leaking ducts can cause the jacket to balloon since the jacket system will be airtight.
  - b. Install outdoor, field-applied jacket on ductwork insulation pitched to shed water and prevent water ponding on top of the duct.
  - c. Fiberglass, urethane, or phenolic foam insulations must have a factory applied FSK facing. Extruded or expanded polystyrene may be faced or unfaced. Contractor is responsible for testing adhesion to any substrate; there are products that have manufacturing release agents (Densglas gold) which will not allow adhesion.
  - d. Substrate surfaces must be clean, dry, and free of oil films.
  - e. Select outdoor, field-applied jacket materials in accordance with manufacturer's instructions for coverage on the underside of the ductwork, to avoid pins.
  - f. Not all outdoor, field-applied jacket materials require pins. See manufacturer's instructions.
  - g. Hot and cold air duct installation for proper maintenance of vapor barrier and physical integrity:
    - 1) Board insulation is mechanically installed on properly sealed duct according to the specifications using insulation fasteners (mini-cup weld pins or perf. based pins and washers).



- 2) Washers are covered with a 4-inch (101.6-mm) square piece of smooth foil tape prior to jacketing the ductwork to prevent the puncture of the outer membrane by the fasteners.
    - 3) Insulation on the top of the ductwork is installed to allow for the water to shed from the top of the duct and to prevent water from ponding on the top of the duct.
  - h. Follow one of the options below for the installation of the outdoor, field-applied jacket depending on the jacket product and the duct sizes:
    - 1) One Piece Installation.
    - 2) Two Piece Installation.
    - 3) Three Piece Installation.
    - 4) Four Piece Installation.
  - i. Select the correct outdoor, field-applied jacket when installing in temperatures below 50 deg F (10 deg C).
  - j. Protect outdoor, field-applied jackets from damaging chemicals. Solvation will occur to the rubberized bitumen when exposed to petroleum or coal tar-based compounds. Contact the manufacturer immediately for more information if there is doubt, before any chemical interaction.
  - k. Allow each piece of the outdoor, field-applied jacket to stretch by using a 6-inch (152.4-mm) lap over the circumferential lap, and a 4-inch (101.6-mm) wide butt lap or overlap over the joint, and then roll with a roller. Position longitudinal laps at a water shed position.
  - l. Do not pre-apply the outdoor, field-applied jacket to fabricated insulation unless metal banding is used. Outdoor, field-applied jackets are not mechanical fastening systems and will not hold the insulation on the duct.
  - m. On hot systems insure that the surface temperature after insulation installation does not exceed the manufacturer's upper temperature use limitations. Heat transfer through single layer joint seams could result in the softening or melting of the rubberized asphalt compound.
  - n. Lay out duct tees and branches using standard sheet metal two-piece methods, modified to allow for overlap seals. Add 1-1/2 inches (38.1-mm) to 2-inches (50.8-mm) to the throat of the bottom half of the fitting. Add 1-1/2 inches (38.1-mm) to the heel of the top half of the fitting. The bottom piece is installed first, and then the top piece lapped over the bottom piece to permit water shedding over the lap. Tees and fittings can be fabricated using standard layout procedures, adding 1-1/2 inches (38.1-mm) to 2-inches (50.8-mm) for the required laps. Fittings can also be gored. Oversize each gore piece to allow for a lap onto the preceding piece. The two-piece method makes a better-looking fitting, however, as with metal work, larger fittings must be gored due to material constraints and ease of application. Standard metal fitting covers can also be used with the outdoor, field-applied jacket products. Insure that the fittings are vapor sealed.
7. Field Quality Control:
- a. Testing Agency: Engage a qualified independent inspecting agency to perform field inspections and prepare inspection reports.
  - b. Perform the field tests and inspections and prepare test reports:
    - 1) Inspect the jackets on the exterior ductwork, piping, and equipment.

- c. All jacketing applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Remove defective Work.
- d. Install new insulation and jackets to replace insulation and jackets removed for inspection. Repeat inspection procedures after new materials are installed.
- e. Obtain written confirmation from jacket manufacturer that completed installation meets manufacturer's installation requirements.

8. Outdoor, Field-Applied Jacket Schedule:

- a. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- b. If more than one material is listed, selection from materials listed is Contractor's option.

1) Outdoor, Field-Applied Jacket Schedule: **Alumaguard All-Weather or Alumaguard All-Weather Cool Wrap**

2.7 OUTDOOR DUCTWORK – SHEET METAL WITH DUCT LINER

- A. At the contractor's option, utilize G90 sheet metal ductwork, lined as specified for exterior duct, with a covering of Polyguard Alumaguard or equal peel and stick weather cover as specified above.

2.8 FLEXIBLE CONNECTIONS

- A. Provide sound isolating flexible connections between connecting ducts and the inlet and outlet of each fan. These connections shall in each case be long enough to permit a minimum separation of 3" between the duct and the fan or unit housing with at least 1" slack in the flexible material itself.
- B. The material shall be of a vinyl coated woven nylon/polyester blend base fabric, 22 oz. per square yard, meeting NFPA 90A and B for flame spread and smoke developed. It shall be fire resistant, waterproof and mildew-resistant. The material shall be equal to Excelon Fabric as manufactured by Duro-Dyne.

2.9 SMOKE DAMPERS

- A. Smoke dampers shall be installed in each duct penetrating a smoke partition. Smoke dampers shall each be motorized fire dampers, Ruskin Type FB90ASM, Class II, DCFM leakage @ 1"SP. Construction shall be in accordance with NFPA 90A. The smoke dampers shall close on a signal from the fire alarm system or the operation of a smoke detector. Provide access doors with ductports in the duct and a ceiling access door at each smoke damper for servicing the damper, motor, and smoke detector. A UL label is required on each smoke damper.

2.10 FIRE DAMPERS

- A. Weighted fire dampers having bronze bearings and held open by fusible links shall be constructed and installed in accordance with the recommendations of the National Fire Protection Association as published in NFPA Bulletin 90A and applicable ordinances and the Building Code. All fire dampers shall have Underwriters' Laboratory labels.
- B. Specifically, fire dampers shall be provided at the points indicated on the drawings, where a duct penetrates a fire rated partition and where a duct penetrates the roof, ceiling, floor or other areas requiring a fire rated separation. They shall also be installed at any other location as required by

applicable codes. Provide access panels in the duct and access doors in the ceiling or wall to service and test the damper. Access doors with vision panes shall be furnished with wire glass.

- C. Furnish fire dampers with fusible links rated for 160 degrees F unless indicated otherwise. Fire dampers shall be constructed of galvanized steel and rated at 1-1/2 hours for partitions and floors rated up to 2 hours, and 3-hour rating for use in partitions and floors rated up to 4 hours unless noted otherwise. Blades shall be of the interlocking type, those in high pressure duct shall be 100% free area and out of the air stream. Fire dampers shall be suitable for either horizontal or vertical mounting as required and shall be furnished with factory fabricated sleeve minimum of two gauges heavier than connecting ductwork.
- D. Fire dampers in low-pressure duct shall be equal to Action Air, Inc. Model 150A. Fire dampers in ceiling air distribution outlets shall be equal to Action Air, Inc. Model 400.

#### 2.11 FIRE/SMOKE DAMPER

- A. Furnish and install a combination fire/smoke damper in all ducts penetrating fire/smoke partitions. Each combination fire and smoke damper shall meet all requirements specified elsewhere for fire dampers and additionally shall include an operating shaft which, when rotated 90 degrees, causes damper to operate between closed and open. Operating shaft and damper combination shall be suitable for linking to and operation by a damper operator. Combination fire/smoke dampers shall be Ruskin type FSD-36, Class II, 250 deg. F., 10 CFM/SF leakage @ 1"SP for low pressure applications and Ruskin type FSD-60, Class I, airfoil blade, 4 CFM/SF @ 1"SP for high pressure applications.
- B. Each combination fire/smoke damper shall be furnished complete with factory sleeve and damper operator factory installed on exterior of sleeve and properly linked to damper operating shaft. Actuator shall be of the spring return fail closed type that will close damper upon power interruption. Damper operators shall be UL listed as fire damper operators and bear the UL label for such. Blade edge seals shall be silicone rubber and galvanized steel mechanically locked into blade edge (adhesive or clip-on seals not acceptable).
- C. The smoke damper shall close on a signal from the fire alarm system or from the operator of a smoke detector.
- D. Provide access doors with ductports in the duct and a ceiling access door if necessary for servicing the damper and actuator.

#### 2.12 ACCESS PANEL

- A. Access doors of sufficient size shall be installed in ducts to permit servicing of contained equipment including fire extinguishing equipment, dampers, etc. Where those panels are in insulated ducts, they shall be double wall panels with material to match the lining and of the same thickness. In uninsulated ducts they shall be single wall construction. All access panels shall have No. 310 Ventlock catches and pulls, No. 260 hinges and No. 390 gaskets.
- B. Where access panels are not exposed or readily accessible above removable ceilings, provide access doors in the general construction.

## 2.13 LINTELS AND WALL PENETRATIONS

- A. The Contractor shall provide and install suitable angle iron lintels where the new ducts pierce walls, and to support walls above duct connections to sidewall grilles, registers, etc. Verify the extent of the work required at the site. Carefully pack with jute and seal around all duct penetrations in wall with mastic.

## PART 3 – EXECUTION

Not Used

END OF SECTION 15400

## SECTION 15500 - HANGERS AND SUPPORTS

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. The Contractor for the work covered by each section of the specifications shall furnish and install all hangers, supports and isolation required by pipe or equipment included in this work.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. Materials shall be provided for the support of all piping and equipment. The following tabulation lists materials suitable for this duty. Equal materials manufactured by Fee and Mason, Carpenter-Patterson, Grinnell or Modern will be considered.

<u>MATERIAL</u>	<u>SERVICE</u>	<u>FEE AND MASON CAT.</u>
Hanger	Copper Tubing 4" and Larger	364 copper plated
Hanger	Copper Tubing 3" and smaller	361 copper plated
Hanger	Steel Lines 3" and smaller	215 or 199
Hanger	Steel lines 4" and larger	239
Hanger	Outside Insulation-all lines	239
Hanger	Cast Iron Lines	239
Hanger	Plastic Pipe	108 + 109
Hanger	Refrigerant Pipe	102
Hanger	Glass Pipe	375
Wall Bracket	All	150, 151, or 155
Saddles	Steel Lines on Rollers	71, 1710, 1712, 172, 173
Conc. Inserts	New Construction	185
Rollers	Steel Piping	161, 272
Pipe Clamps	2" and Smaller	304
Pipe Clamps	3" and Larger	241
Pipe Rest	All	295 or 291
Exp Shield	Concrete	374
Beam Clamps	All	249, 254, 255, 282, 280
Adjuster	All	2381

## 2.2 HANGER RODS

- A. All individually suspended horizontal pipes shall be supported by steel rods sized as follows:

Rod Diameter	Size of Steel Pipe or Copper Tube Supported	Size of Cast Iron Pipe Supported
3/8"	2-1/2" and smaller	3" and smaller
1/2"	3" and 4"	4" through 6"
5/8"	5" through 8"	8" through 10"
3/4"	10" and larger	12" and larger

## 2.3 HANGER SPACING

- A. All hangers shall be so located as to properly support horizontal lines without appreciable sagging of these lines. The following table gives minimum spacing for copper, and steel lines, but hangers shall be more closely spaced where necessitated by conditions or the type of pipe involved or required by code.

Size of Line	Hanger Spacing in Feet
3/4" and smaller	5
1" through 1-1/2"	7
2" and larger	10
All cast iron lines	5 (Minimum two per joint)

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF SUPPORTS

- A. All pipes shall be adequately supported. All piping shall be installed with due regard to expansion and contraction, and the type of hanger, method of support, location of supports, etc. shall be governed in part by this consideration. Transmission of vibration and noise shall also be considered and any special suspension with vibration dampeners required to minimize transmissions shall be used where specified or required.
- B. All exposed vertical risers running near walls shall be supported from the walls. Each line shall have a minimum of 2 supports, not greater than 10'0" on centers, with the additional provision that there shall be a support near the top of the riser. All supports shall be aligned.
- C. All vertical pipes shall be supported with riser clamps sized to fit the lines and to adequately support their weight. At the bases of lines, where required for proper supports, furnish and install anchor base fittings or other approved supports.
- D. Where vertical lines run down to a point near the floor and a support is needed, they may be supported by means of a pipe leg welded to the pipe, extending down to the floor and terminating in a capped end resting on the floor.
- E. Where pipes other than those specified hereinbefore, are running along walls, they shall be supported using hangers as described hereinbefore, but suspended from brackets bolted to the wall. Specially fabricated clips or U-braces may be used where commercially manufactured items are not available in the proper size.

- F. Where pipes or equipment are suspended under existing concrete construction, drill and use Grinnell Fig. 117 expansion case or Phillips concrete fasteners in sizes not exceeding 1/2" and for loads of 200 lbs. or less. For larger rods or loads above 200 lbs. drill through the beam above the bottom steel and bolt a Grinnell Fig. 202 bracket to the side of the beam for support. Size brackets per manufacturer's recommendations. Use pipe stands where required.
- G. Where multiple lines are run horizontally at the same elevations and grades, they may be supported on trapezes formed for sections of Unistrut, angle iron, or channels suspended on rods or pipes. Trapeze members, including the suspension rods, shall be properly sized for the number, size and loaded weight of the lines they are to support. Trapeze spacings shall be in accordance with the preceding table for the smallest line supported on or from the trapezes.
- H. Hangers supporting insulated lines which are specified to be finished with a vapor seal shall be fitted outside the insulation. The insulation on horizontal lines shall be protected by low compression insulation shields. On all pipes the shields shall be Fee and Mason Fig. 81 or rolled 14-gauge galvanized. The shields on horizontal lines shall be positioned so that they encompass the bottom of the pipe and are centered on the hanger or support. On vertical lines there shall be two shields of the same type full encompassing the pipe at each clamp. Shields shall be secured with a 3/4" wide lacquered steel band at each end.

### 3.2 COOPERATION BETWEEN TRADES

- A. Where pipes specified under different sections may possibly be racked on the same supporting structure, each trade shall cooperate with the others involved to properly locate the supporting members and shall furnish a proportionate share of the labor and materials involved in the installation.
- B. Any other special hangers and supports shall be provided and installed as indicated on the drawings, specified elsewhere herein or required by conditions at the site.

### 3.3 DUCT HANGERS

- A. All ductwork shall be supported in accordance with standards published by Sheet Metal and Air Conditioning Contractors National Association Inc.

### 3.4 DUCT SUPPORTS

- A. Product Name: DUCT SUPPORTS MODEL NO. 6-DS, 6-DSA, 8-DS AND 8-DSA. NOTE: Duct Supports are given model numbers which correspond to the allowable loads. 6-DS and the 6-DSA are used for lighter, smaller duct and 8-DS and the 8-DSA are for heavier, larger duct. All duct supports are manufactured custom at the MIRO Industries plant.
- B. Design Emphasis: The 6-DS, 6-DSA, 8-DS and 8-DSA duct support has been designed specifically for square and round duct work. The versatility of the design for this product enables it to expand to hold any number of duct running along the roof for maximum efficiency and cost savings to customers, contractors, and owners. Thus, this duct support product can be used to hold ganged duct or stacked duct across and at varying heights above the roof. See below.
- C. Manufacturer: MIRO INDUSTRIES, INC., 2700 South 900 West, Salt Lake City, Utah 84119; Phone (800) 768-6978; Fax (800) 440-7958

- D. **Product Description:** A frame constructed of strut and MIRO's patented bases are used to support duct on flat roofs. Unique design allows a sturdy support without penetrating or causing damage to the roof membrane. Ducts rest on a 1-5/8" x 1-5/8" or 1-5/8" x 7/8" strut and are adjustable in height. All 6-DSA and 8-DSA models are manufactured in a 12-gauge telescoping design for maximum adjustability in length and height. The duct support base is made of stainless steel, hot-dip galvanized steel or polycarbonate plastic and all other metal parts are made of hot-dip galvanized steel.
- E. **Product Performance:** The frame system serves to keep the duct system directly over and beneath the frame without binding and allows for some lateral expansion of the duct system. The base is gently rounded to prevent gouging. Drainage ports are provided to prevent ponding within the device.
- F. **Compatibility:** MIRO Duct Supports are recommended for use on and are compatible with all current types of decking and with all commonly used built-up and single-ply roofing membranes where roof-mounted ducts occur. With heavier loads it is prudent to use a MIRO Support Pad or other traffic pad to further protect the roof membrane.
- G. **Load Weight:**
1. 6-DS: Maximum load weight not to exceed 300 lbs. per duct support or 150 lbs. on each base
  2. 6-DSA: Maximum load weight not to exceed 150 lbs. per duct support or 75 lbs. on each base or 20" spiral duct
  3. 8-DS: Maximum load weight not to exceed 700 lbs. per duct support or 350 lbs. on each base
  4. 8-DSA: Maximum load weight not to exceed 300 lbs. per duct support or 150 lbs. on each base or 26" spiral duct
- H. **Composition and Materials:** The pipe stand consists of two major components: (1) Two roof deck bases of stainless, hot-dip galvanized steel or polycarbonate plastic which set upon the roof membrane, (2) A braced strut or telescoping assembly which is supported by, rests upon, and is connected to the two bases.
- I. **Size:** Support Models are made as follows: Each of the two deck bases 12" x 16", 9" x 15.25", 12.07" x 16", 9" x 31.69" or 18" x 16". The 6-DS has a bar width which allows at least 10" between strut assembly and can adjust in height to support duct from a low of 12" to a desired height. The 6-DSA has a bar width which allows at least 18" between strut assembly and can adjust in height to support duct from a low of 10" to a high of 24". The 8-DS-SB has a bar width which allows at least 16" between strut assembly and can adjust in height to support duct from a low of 12" to a desired height. The 8-DS-DB has a bar width which allows at least 12" between strut assembly and can adjust in height from a low of 12" to a desired height. The 8-DSA has a bar width that allows at least 24" between strut assembly and can adjust in height to support duct from a low of 10" up to a high of 36". The strut is 1-5/8" x 7/8" or 1-5/8" square, the telescoping is 1-5/8" and is constructed at various heights to give duct clearance adjustment above the roof plus or minus. The 6-DSA and the 8-DSA are also adjustable by width.
- J. **Adjustable Height:** The Models 6-DS, 6-DSA, 8-DS and 8-DSA and its related configurations allow adjustable height as desired or required by the code or roof system. Each model can be configured to allow plus or minus height above the roof. Cross-bracing two pipe stands every 4th or 5th pipe stand is recommended and required for elevations 36" and higher. Purchasers should specify desired heights upon ordering the duct supports.



- K. Installation Process: (1) Center the duct support beneath the duct so that the frame allows the duct to be squarely over and through the horizontal bar. (2) Adjust the duct support to the desired height and to even load with other duct supports. Make certain the horizontal support strut is level. (3) Set the duct in the horizontal bar without dropping or causing undue impact. For heavier loads it is prudent to install an additional sheet of roofing material, a MIRO Deck Plate, or MIRO Support Pad beneath the duct support. For built-up roofs, all loose aggregate from an area 2" larger than each base should be removed from the area directly beneath the duct support and then follow the installation directions set forth above. Care should be taken to install each duct support, so it supports a proportional and equal amount of weight at each duct support.

OPTIONAL METHOD OF INSTALLATION (Not Recommended): Where code requires or as desired, the duct supports may be attached to the roof structure by appropriate and compatible rooftop fasteners through holes then drilled in the bases' pitch pan at the time of installation. After attachment has been made to the roof, the pitch pan may be filled with asphalt material or cement to help seal the areas around the fasteners.

- L. Spacing: Manufacturer's recommended spacing is not to exceed 8-foot centers depending upon the load. Do not exceed load weight and make certain each duct support is adjusted in height to even load at all duct supports.
- M. Availability: Duct Supports are marketed throughout the United States through representatives and distributors.
- N. Maintenance: Normally maintenance is not required. Semi-annual inspection is required to check duct support position and set duct alignment, weight distribution and improper installation which may cause duct support damage or failure.
- O. Technical Services: Please call MIRO INDUSTRIES, INC.: (800) 768-6978 or visit our website [www.miroind.com](http://www.miroind.com) for technical information and for graphic and CAD drawing downloads.

### 3.5 PRE-FABRICATED EQUIPMENT MOUNTING SUPPORTS

- A. Provide ThyCurb equipment mounting supports or approved equal of 18 ga. galvanized construction with continuously welded corner seams and a 3" cant, supports to be internally reinforced with a factory installed wood nailer and 18 ga. counterflashing. Supports to be a minimum of 8" above the finished roof and of the style and design to mate the roof deck.
- B. Supports shall be level at the top, with pitch built into supports where roof slopes 3/8 of an inch per foot or more and supports must have certified load bearing data. Supports must span a minimum of 2 joists and more if equipment length requires it. Supports to be used for all roof mounted equipment, HVAC units, condensing units and roof mounted piping.

END OF SECTION 15500

## SECTION 15550 - VIBRATION ISOLATION

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Conform with applicable provisions of the General Conditions, Special Conditions, General Requirements, and Supplemental Conditions.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. The Contractor for the work covered by each section of the specifications shall furnish and install all vibration isolation required by pipe or equipment included in this work.

### PART 2 - MATERIALS

#### 2.1 ISOLATION

- A. Mechanical equipment and associated piping and ductwork shall be mounted on vibration isolators as specified and required to minimize transmission of vibrations and structure borne noise to building structure or spaces.
- B. All rotating equipment shall be balanced both statically and dynamically. The equipment supporting structure shall not have any natural frequencies within plus or minus 30% of the operating speeds. The equipment when mounted and placed in operation shall not exceed a self-excited vibration velocity of 0.10" per second when measured with a vibration meter on the bearing caps of the machine in the vertical, horizontal and axial directions or measured at the equipment mounting feet if the bearings are concealed.
- C. Isolation shall be stable during starting and stopping of equipment without any traverse and eccentric movement of equipment that would damage or adversely affect the equipment or attachments.
- D. Isolation shall be selected for the lowest operating speed of equipment.
- E. Isolation shall be selected and located to produce uniform loading and deflection even if equipment weight is not evenly distributed.
- F. Fiberglass Isolators: Fiberglass isolators shall consist of a high-density matrix of precompressed molded glass fibers enclosed in a resilient neoprene jacket. Fiberglass isolators shall be equal to Consolidated Kinetics Corporation isolators. Isolators shall be selected for the actual loads of equipment served and generally shall be 90% efficient or better.
- G. Neoprene Pads: Neoprene pads shall be of cross ribbed or waffle design and a minimum of 5/16" thick. Where concentrated load bearing is encountered, steel-bearing plates shall be bonded to

neoprene pads to spread the load. The neoprene pads shall be sized for a load of 50 pounds per square inch.

- H. Spring Isolators: Spring isolators shall be free standing, laterally stable without any housing, and complete with neoprene acoustical friction pads, a minimum of 1/4" thick between the base plate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment or base. Coil outside diameters shall not be less than 0.8 of the operating height of the spring. Spring shall have an additional travel to solid equal to 50% of the operating deflection. The horizontal stiffness of spring isolators shall be not less than 0.8 of the vertical axial stiffness. All spring isolators shall be selected for 1" initial deflection or more. Isolators for air units shall be selected for 2" deflection. Isolators shall be galvanized where installed outside.

### PART 3 - EXECUTION

#### 3.1 VIBRATION ISOLATION HANGERS AND SUPPORTS FOR PIPES AND DUCTS

- A. Furnish vibration isolation in accordance with the following:
1. Each pipe connected to equipment mounted on vibration isolators shall have a minimum of 3 spring hangers.
  2. Hanger vibration isolators shall be selected for not less than the deflection provided for the equipment to which the piping is connected. The vibration isolator units selected shall accommodate the thermal movement of the piping systems.

#### 3.2 SCHEDULE OF VIBRATION ISOLATION

EQUIPMENT	PRIMARY ISOLATION	SECONDARY ISOLATION
PRV Type Fans	Neoprene Pads	
Utility Vent Fans	Spring Isolators - 1"	
Rooftop DOAS Units	Internal Isolators	

END OF SECTION 15550

## SECTION 15600 - INSULATION

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SUBMITTALS

- A. Submit manufacturer's data on all materials.

#### 1.3 SCOPE

- A. This section of the specifications comprises the furnishing of all labor, materials, transportation, tools and appliances and in performing all operations in connection with the installation of thermal insulation, coverings, jackets, supports, shields, etc. as described herein and/or as shown on the accompanying drawings, or reasonably implied therefrom. All surfaces which may vary from the ambient temperature shall be insulated unless specifically accepted.

### PART 2 - PRODUCTS

#### 2.1 MATERIALS

- A. In describing the various materials, application procedures, and finishes, each item will be described singularly, even though there may be a multiplicity of identical applications. Also where the description is only general in nature, exact dimensions, arrangements and other data shall be determined by reference to plans, schedules, and details, including those provided by equipment manufacturers.
- B. Where materials are described under other sections of the specifications and are pertinent to this section, they shall be installed hereunder as though they were repeated herein.
- C. All insulation shall have composite fire and smoke hazard ratings as tested by procedure NFPA 225, not exceeding flame spread 25, smoke developed 50. Accessories such as adhesives, mastics, cement, tape, cloth, etc. shall have these same component ratings.
- D. All materials installed under this section of the specifications shall be manufactured in the United States of America.

#### 2.2 VAPOR BARRIER JACKETS

- A. Factory-applied vapor-barrier jackets shall be laminated of flame resistant white kraft paper and .001-inch aluminum foil reinforced with glass fiber fabric between the foil and the paper. The foil and paper shall be adhered with a flame-resistant latex adhesive.
- B. Where specified, insulate valves and fittings with two fiberglass inserts and preformed Manville "Zeston" covers with taped seams.

- C. Where metal jackets are specified, they shall be 0.016" thick No. 5005 tempered aluminum secured with machine drawn 0.020" stainless steel bands.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

- A. The installation of all thermal insulation shall be performed by a recognized firm regularly engaged in the insulation business, using skilled insulation mechanics and using insulation materials which are the product of reputable manufacturer of the materials, using any special materials as required by these specifications and by those published standards.
- B. Any insulation which is not applied in a workmanlike manner will be rejected and replaced. All coverings shall be smooth, flush, dressed to line and tight. Mastic shall be neatly applied and tooled. The Architect reserves the right to reject any insulation whose appearance he deems unacceptable.

### 3.2 APPLICATION OF INSULATION

- A. Apply insulation and pipe covering after all work has been tested, found to be tight and accepted as such by the Architect. Thoroughly clean and dry all surfaces to be covered.
- B. Apply rigid insulation board on flat sheet metal surfaces with Foster No. 85-60 or Childers CP-127 adhesive and additionally secure with Graham pins or adhesive clips on 12" centers. No penetration of the metal will be permitted. Fill all joints with seam filler and strip with an open woven glass fabric tape. Trowel Foster No. 30-65 or Childers CP-34 vapor barrier coating over all joints and clips to a 1/8-inch thickness and wipe to eliminate pinholes.
- C. On glass fiber pipe covering with factory-applied vapor-barrier jacket, lap the jacket on the longitudinal seams and seal with vapor barrier lap adhesive equal to Foster 85-60 or Childers CP-82 or use self-sealing lap. Tightly butt the ends and cover butt joints with a 4" wide band of vapor barrier jacket secured with the same adhesive.
- D. Except where insulation is cloth jacketed, band all pipe insulation, following the completion of painting operations. Bands shall be aluminum not less than 3/4-inch wide. Space bands a maximum of 12" on centers, with three bands per section of covering. Where sections of insulation are overlapped as at flanges, apply a band at each of the overlapping sections and one on the basic line covering immediately adjacent to the end of the overlap. Provide bands also on each side of each valve, fitting, etc. and at the end terminal where the insulation is beveled off as specified herein. Also band the hanger shields on insulated cold lines with a band at each end of each shield.
- E. Exclusions: No insulation shall be applied to:
  - 1. The cooling leg at a steam trap--the piping from the scale pocket ahead of the trap to the line on the outlet of the union following the trap.
  - 2. Expansion tanks.
  - 3. Exposed chrome plated lines.

### 3.3 INSULATION ON EQUIPMENT AND PIPING SYSTEMS

- A. The following describes materials, thicknesses and finishes for insulation and coverings. In the following, the word "exposed" shall apply to any line, duct, or other material or surface in any room

above the lowest floor in any building unit, exterior to the building and above ground, and/or in equipment rooms; the word "concealed" shall apply to any line, duct, or other material or surface in other underfloor areas, ceiling spaces furrings and chases.

- B. Also included in this section is the requirement for patching and repair of existing insulation where new connections are made.
  - 1. Duct Insulation: Refer to Section 'AIR DISTRIBUTION' for duct liner and exterior duct specification.

END OF SECTION 15600

## SECTION 15710 – PACKAGED ROOFTOP UNITS / OUTDOOR AIR HANDLING UNITS

### PART 1 – GENERAL

#### 1.1 GENERAL DESCRIPTION

- A. This section includes the design, controls and installation requirements for packaged rooftop units / outdoor air handling units.

#### 1.2 QUALITY ASSURANCE

- A. Packaged air-cooled condenser units shall be rated in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.
- B. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- D. Unit shall be certified in accordance with ANSI Z21.47b/CSA 2.3b and ANSI Z83.8/CSA 2.6, Safety Standard Gas-Fired Furnaces.
- E. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
- F. Unit shall be safety certified by ETL and ETL US listed. Unit nameplate shall include the ETL/ETL Canada label.

#### 1.3 SUBMITTALS

- A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation, and Maintenance manual with startup requirements shall be provided.
- B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

#### 1.4 DELIVERY, STORAGE, AND HANDLING

- A. Unit shall be shipped with doors screwed shut and outside air hood closed to prevent damage during transport and thereafter while in storage awaiting installation.
- B. Follow Installation, Operation, and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

- C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation, and Maintenance manual.

## 1.5 WARRANTY

- A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for Installation, Operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and filters.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURER

- A. Products shall be provided by the following manufacturers:
  - 1. AAON
  - 2. Substitute equipment may be considered for approval that includes at a minimum:
    - a. Direct drive supply fans
    - b. Double wall cabinet construction
    - c. Insulation with a minimum R-value of 13
    - d. Stainless steel drain pans

### 2.2 ROOFTOP UNITS

- A. General Description:
  - 1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, reheat coil, gas heaters, exhaust fans, energy recovery wheels, and unit controls.
  - 2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment’s literature pocket.
  - 3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
  - 4. Unit components shall be labeled, including and electrical and controls components.
  - 5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
  - 6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
  - 7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment’s hinged access door.
  - 8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment’s hinged access door.
- B. Construction:
  - 1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.



2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, heaters, energy recovery wheels, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless-steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.
11. Unit base shall be fabricated of 1-inch-thick double wall, impact resistant, rigid polyurethane foam panels.
12. Unit shall include factory installed welded wire mesh screen on the face of the condenser coil.

C. Electrical:

1. Unit shall have a 5kAIC SCCR.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

D. Supply Fans:

1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
4. Variable frequency drives shall be factory wired and mounted in the unit.

E. Exhaust Fans:

1. Exhaust dampers shall be sized for 100% relief.
2. Fans and motors shall be dynamically balanced.
3. Unit shall include barometric relief dampers.

4. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.
5. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn lockable handles.
6. Unit shall include belt driven, unhooded, backward curved, plenum exhaust fans.
7. Variable frequency drives shall be factory wired and mounted in the unit.

F. Cooling Coils:

1. Evaporator Coils:
  - a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
  - b. Coils shall have interlaced circuitry and shall be 6 row high capacity.
  - c. Coils shall be hydrogen or helium leak tested.
  - d. Coils shall be furnished with factory installed expansion valves.

G. Refrigeration System:

1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be scroll type with thermal overload protection and carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory.
3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.
4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.
5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.
6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low-pressure sides and a factory installed liquid line filter driers.
7. Lag refrigeration circuits shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
8. Reheat coil shall be multi-pass and fabricated from aluminum microchannel tubes. The reheat coil shall be piped in parallel with the condensing unit.

H. Condensers:

1. Air-Cooled Condenser:
  - a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.
  - b. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
  - c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
  - d. Coils shall be hydrogen or helium leak tested.

- e. Condenser fans shall be high efficiency electrically commutated motor driven with factory installed head pressure control module. Condenser airflow shall continuously modulate based on head pressure and cooling operation shall be allowed down to 35°F with adjustable compressor lockout.

I. Gas Heating:

1. Stainless steel heat exchanger furnace shall carry a 25-year non-prorated warranty, from the date of original equipment shipment from the factory.
2. Gas furnace shall consist of stainless-steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.
3. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.
4. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.
5. Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the control compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet.

J. Filters: Unit shall include 2-inch thick, pleated panel filters with an ASHRAE MERV rating of 8, upstream of the cooling coil.

K. Outside Air/Economizer: Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return actuator. Unit shall include outside air opening bird screen, outside air hood, and relief dampers.

L. Energy Recovery:

1. Unit shall contain factory mounted and tested energy recovery wheels. The energy recovery wheels shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
3. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

4. Unit shall include 2-inch thick, pleated panel outside air filters with an ASHRAE MERV rating of 8, upstream of the wheels.
5. Hinged service access doors shall allow access to the wheels.

M. Polymer Energy Recovery Wheels:

1. Shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
2. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive.
3. Polymer Energy recovery wheel cassette shall carry a 5-year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard AAON limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5-year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18-month warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.
4. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

N. Controls:

1. Factory Installed and Factory Provided Controller:

- a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
- b. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
- c. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
- d. Makeup Air Controller:
  - 1) Unit shall modulate cooling with constant airflow to meet ventilation outside air loads. Cooling capacity shall modulate based on supply air temperature.
  - 2) With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet outside air humidity loads and prevent supply air temperature swings and overcooling of the space.

- 3) Unit shall modulate heating with constant airflow to meet ventilation outside air loads. Heating capacity shall modulate based on supply air temperature.
  - 4) Unit shall deliver filtered, dehumidified, neutral temperature air to the locations shown on the drawings. Provide all microprocessor controls onboard as required to control the unit. Provide BACnet card with MS/TP protocol technology to interconnect to Johnson Controls Metasys. Coordinate all details prior to bid.
- e. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a LonWorks or BACnet network. [Orion Controls System]

## 2.3 CURBS

- A. Mount the units on the existing steel frames that currently support the chillers and the emergency generator. Refer to the drawings for details.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, OPERATION, AND MAINTENANCE

- A. Installation, Operation, and Maintenance manual shall be supplied with the unit.
- B. Installing contractor shall install unit, including field installed components, in accordance with Installation, Operation, and Maintenance manual instructions.
- C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

END OF SECTION 15710

## SECTION 15800 - TESTING, ADJUSTING AND BALANCING MECHANICAL SYSTEMS

### PART 1 - GENERAL

#### 1.1 NOTE

- A. Drawings, General Conditions of the Contract for Construction, Supplementary Conditions and Division 1 - General Requirements apply to Work of this Section.

#### 1.2 SCOPE

- A. The contractor shall include in his bid an amount necessary to perform and submit a certified TAB report. This section of the specifications comprises the furnishing of all labor, materials, transportation, tools and appliances and in performing all operations in connection with the testing, balancing and adjusting of various systems and portions thereof to produce proper flows of air and water, correct setting of regulation devices, and other end results as more fully described hereinafter.
- B. Upon completion of the installation and start-up of the mechanical equipment, check, adjust, and balance systemic components to obtain optimum conditions in each conditioned space to the building.
- C. Prepare and submit to the Engineer complete reports on the balance and operation of the system.
- D. Make inspections in the building during the opposite season from that in which the initial adjustments were made and at those times make any necessary modifications to the initial adjustments required to produce optimum operation of the systemic components, to produce the proper conditions in each conditioned space.
- E. In all fan systems, the air quantities shown on the plans may be varied as required to secure a maximum temperature variation of 2 degrees within each separately controlled zone, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drives and/or motors, if necessary, without cost to the Owner, to attain the specified air volumes.
- F. Before final acceptance is made, furnish the following data:
  - 1. A tabulation of the simultaneous temperature of all spaces on each separately controlled zone, together with the outside temperature at time of measurement.
  - 2. A listing of the measured air quantities at each outlet corresponding to the temperature tabulation specified above.
  - 3. Air quantities at each return and exhaust air handling device.
  - 4. Flow rate and temperature at each coil and heating device.
  - 5. Static pressure readings entering and leaving each supply, and exhaust fan, and other components of the system. These readings shall be related to fan curves in terms of CFM handled.
  - 6. Motor current readings at each fan and pump. The voltages at the time of the reading shall be listed.

- G. The above data shall be neatly entered on appropriate forms together with any typed supplements required to completely document all results. Written explanations of any abnormal conditions shall be included. All this shall be assembled into a document and submitted electronically.
- H. When opposite season modifications are made, additional data sheets indicating new settings, readings, etc., shall be prepared and submitted.

### 1.3 INSTRUCTIONS

- A. During the test periods instruct the building operating personnel in the operation and maintenance of all equipment.
- B. Deliver to the Owner 3 complete instruction manuals covering the maintenance and operation of the system components. In addition, provide schematic wiring diagrams of each piece of equipment framed under glass and mounted on the wall as directed. Provide complete data on all equipment, including for each item a parts list, and the name and address of the vendor where replacement parts can be purchased.

## PART 2 – PRODUCTS

Not Used

## PART 3 – EXECUTION

Not Used

END OF SECTION 15800

## SECTION 15900 – TEMPERATURE REGULATION

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

#### 1.2 SUMMARY

- A. This Section includes control equipment for HVAC systems and components.

#### 1.3 DEFINITIONS

- A. FMS: Facility Management System.
- B. ASC: Application Specific Controller.
- C. BMS: Building Management System.
- D. DDC: Direct Digital Control
- E. GUI: Graphical User Interface
- F. HVAC: Heating, Ventilation, and Air Conditioning
- G. LAN: Local Area Network.
- H. PID: Proportional, Integral, Derivative
- I. NAE: Network Automation Engineer
- J. UNT: Unitary Controller
- K. VAV: Variable Air Volume
- L. UDP: User Datagram Protocol

#### 1.4 SCOPE

- A. The existing BMS system at Lamar County Courthouse was originally installed in 2004. It is well past due for modernization. Install a new Network Server and a Network Engine for this application. Provide cybersecurity enhancements which will protect the system from 3rd party infiltration. The network engine shall have capacity for (2) communication trunks.
- B. The existing devices shall continue to report to the new Network engine using previously configured N2 communications. The new devices (boilers, Chillers, Aeon AHU) will communicate via BACnet to the Network engine.



- C. The enhanced Metasys User Experience shall enhance the day-to-day functionality and operation of the existing system. Additionally, in conjunction with the IT department for Lamar County, temperature control contractor shall provide the capability to monitor the system from remote locations using laptop or tablet technology.
- D. A new Network Server is included in this installation. The Network Server will consist of the following:
1. The Application and Data Server (ADS) Turnkey system uses a Dell OptiPlex XE3 small form factor industrial grade desktop, pre-loaded with Microsoft Windows 10 IoT operating system (OS), Microsoft SQL Server Express database software, other third-party software components, and the latest release of Metasys software. Turnkey systems ship ready to connect to your customers' building networks. A 24" VGA/DVI monitor is included.
- E. Johnson Controls shall provide the following:
1. Furnish and install a new network engine to integrate to both the existing N2 system currently installed at the Courthouse as well as the new mechanical equipment being furnished by others.
  2. Extend N2 communication bus as needed to connect to new Network Engine referenced above. Connect to the existing Metasys N2 trunk to bring in all existing controllers and devices previously installed in 2004. The existing N2 devices are reported to be working as originally configured at this time. No repairs or replacements are included in the scope of work. If repairs or replacements are necessary, submit change order pricing for consideration.
  3. Furnish and install CAT5 BACnet IP or BACnet MSTP wiring from the new Network Engine to each of the new mechanical systems scheduled to be installed at the Courthouse, this includes BACnet integration to the (2) new Aerco boilers and two new Aeon outside air units (DOAS). BACnet protocols or interface cards for the integrations are specified for the DOAS and Chillers. Coordinate connections prior to bid!
  4. Furnish and install Metasys Application Data Server to monitor and control both the existing systems and the new integrations referenced above.
  5. All work shall be performed during normal working hours.
- F. General Notes:
1. All low voltage control wiring will be furnished and installed by JCI to connect the new equipment being furnished by others.
  2. All raceways for controls wiring shall be provided by JCI. Where possible, we will provide plenum cable for concealed wiring in ceilings. Provide EMT or PVC conduit for electrical work that is in mechanical rooms, Provide rigid conduit in all exposed locations. Refer to division 16 for wiring and conduit specifications.
  3. Temperature Control Contractor (TCC) shall pull Metasys BMS communication wire necessary to connect the Metasys BMS communications bus to both the existing and new equipment as required.
  4. JCI will furnish and install system graphics and the Metasys User Interface database reflecting all of the enhancements delineated above. We will also provide new system graphics for the existing systems.

G. Temperature control section exclusions:

1. Temperature Control Contractor shall provide 120VAC power wiring to the new Network Engine panel. All other power wiring shall be by Division 16.
2. All BACnet interface cards shall be supplied by equipment manufacturers and are not included in Temperature Control scope. Interconnection to BACnet cards and commissioning of all sequences is in the scope of work.
3. Repairs to existing controls. If necessary, TCC will provide a quotation to cover the cost of any recommended repairs.
4. Hardwired start/stop or other ancillary monitoring points are excluded from the TCC scope but included in the equipment supplier scope. The BACnet integrations will provide both read/write capacity to control the new equipment furnished by others.
5. Ancillary interlock wiring between the boilers and their associated pump(s) is not included in TCC scope, but existing boiler sequence exists and shall remain.
6. Any ancillary control wiring or controls hardware and installation requirements for the control of the DOAS unit is not included. DOAS control shall be by the DOAS manufacturer. Interconnection between DOAS controls and TCC shall be coordinated prior to bis.

1.5 FMS DESCRIPTION

- A. The FMS shall be a complete system designed for use on Intranets and the Internet. This functionality shall extend into the equipment rooms. Contractor shall be responsible for coordination with the owner's IT staff to ensure that the FMS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
- B. All points of user interface shall be on standard PCs that do not require the purchase of any special software from the FMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser such as Internet Explorer.
- C. The FMS work shall consist of all labor, materials, tools, equipment, software, software licenses, wiring, tubing, installation, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, management, warranties, services and items as Specified in these Division documents which are required for the complete, fully functional and commissioned FMS.

1.6 QUALITY ASSURANCE

- A. Bids by wholesalers, franchised, and non-franchised contractors shall not be acceptable.
- B. The system manufacturer shall, as a minimum, manufacture and supply the Application Specific Controllers, Supervisory Controllers, Graphical User Interface, damper actuators, and valve actuator assembly.
- C. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the direct employment of the temperature control system manufacturer.

- D. The Building Management System contractor shall have a full-service facility that is staffed with engineers in Johnson Controls systems and technicians fully capable of providing instructions and routine emergency maintenance service on all Johnson Controls system components.
- E. Mechanical equipment manufacturers desiring to provide DDC type controls as factory mounted equipment shall not be acceptable.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- G. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."
- H. Comply with National Electric Code.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

#### 1.8 COORDINATION

- A. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.
- B. Coordinate supply of conditioned electrical circuits for control units and panels. Electrical circuits provided by division 26 contractor.

#### 1.9 SYSTEM INSTALLATION GUIDELINES

- A. All exposed temperature control and interlock wiring shall be installed in conduit, unless otherwise noted on the plans. Power or interlock wiring shall be run in separate conduit from sensor and communications wiring.
- B. All non-plenum rated cable will be run in conduit from termination-to-termination points.
- C. Plenum rated cabling run in the return plenum above dropped ceilings does not need to be run in conduit but shall be installed and supported as close as possible to the structural members. Main cable bundles shall, in general, run above Corridor ceilings, with individual cables extending above ceiling to the terminal units. Cable shall not lay on the ceiling grid, lights, ductwork etc. It will be run at right angles, parallel and perpendicular to the building lines with run outs into rooms being perpendicular to the main cable bundles.
- D. All wiring within Mechanical Rooms or Air Handling Rooms shall be run in conduit. Wiring extending from these rooms shall be installed in conduit that extends a minimum of 12" beyond the mechanical room wall. Remote satellite boxes used for housing control transformers shall be located above accessible ceilings of Corridors within 10 feet of mechanical rooms. Control transformers shall not be installed above ceilings of limited access areas such as offices, conference rooms, office suites, etc. or above non-accessible ceilings.

- E. All plenum rated cabling run in standard drywall construction will be run inside the wall in new or existing conduit which extends six inches above the top plate of the wall and exiting the wall through standard wall boxes.
  - F. On wall constructed of solid concrete, cinder block or plaster, cables will be run in concealed conduit, surface wire mold or another approved raceway.
  - G. No ceiling tiles will be removed, or holes punched out to accommodate cable penetration into a room.
  - H. Cabling shall be bundled neatly and well secured using nylon zip straps. It shall not be wrapped around piping or conduit. Support cabling at walls, to sub-ceiling or structural steel with wall locks or clamps. Cabling shall not be installed with excessive slack.
  - I. Cables requiring crimp-on connectors must have those connectors attached with an appropriate and recommended specialized crimping tool.
  - J. Identify each item, mounted on the face of a control panel, with a label (1/4" letters minimum).
  - K. Thermostats or sensors mounted on outside walls shall be mounted on an insulated mounting base (or equal).
  - L. All sensor elements in water lines shall be installed in separable wells, packed with heat conductive compound.
- 1.10 SYSTEM PERFORMANCE
- A. Performance Standards. The system shall conform to the following:
    - 1. Graphic Display. The system shall display a graphic with 20 dynamic points with all current data within 20 seconds.
    - 2. Graphic Refresh. The system shall update a graphic with 20 dynamic points with all current data within 20 seconds.
    - 3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be less than 5 seconds. Analog objects should start to adjust within 5 seconds.
    - 4. Object Scan. All changes of state and change of analog values will be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be updated within 60 seconds.
    - 5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall be 20 seconds.
    - 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
    - 7. Performance. Digital controllers shall be able to execute DDC PID control loops at a selectable frequency of at least once per second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
    - 8. Multiple Alarm Annunciation. All workstations on the network must receive alarms within 5 seconds of each other.

9. Reporting Accuracy. The system shall report all values with an end-to-end accuracy as listed or better than those listed below:

Measure Variable	Reported Accuracy
Space Temperature	±1°F
Ducted Air	±1°F
Outside Air	±2°F
Dew point	±3°F
Water Temperature	±1°F
Relative Humidity	±5% RH
Water Flow	±5% of full scale
Airflow (terminal)	±10% of reading
Airflow (measuring stations)	±5% of full scale
Air Pressure (ducts)	±0.1 "W.G.
Air Pressure (space)	±0.01 "W.G.
Water Pressure	±2% of full scale (absolute or differential)
Electrical	5% of reading (A, V, W, Power factor)
Carbon Dioxide (CO2)	±5% of reading

10. Stability of Control. Control loops shall maintain measured variable at set point within the tolerances listed below:

Controlled Control Range of Variable Accuracy	
Medium	
Air Pressure	±0.2" w.g. 0-6" w.g. ±0.01" w.g. 0.1 to 0.1" w.g.
Airflow	± 5% of full scale
Temperature	±1.0°F
Humidity	±5% RH
Fluid Pressure	±1.5 psi 1-150 psi ±1.0" w.g. 0-50"w.g. differential

#### 1.11 WORK BY OTHERS

- A. Smoke detectors shall be furnished and installed by the electrical contractor. The temperature controls subcontractor shall be responsible for interlock wiring between the smoke detectors and the air handling unit safety circuits.
- B. Motor starters shall be furnished and installed by the mechanical contractor. The temperature controls subcontractor shall be responsible for all wiring necessary involving the starter to perform the sequence of operation specified.
- C. All temperature wells, taps, dampers and actuated control valves shall be installed by the mechanical contractor.

#### 1.12 QUALITY ASSURANCE

- A. Five (5) copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's catalog data sheets and

installation instructions. Shop drawings shall also contain complete wiring and schematic diagrams, software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

- B. A complete written Sequence of Operation as well as a hard copy graphical depiction of the application control programs shall also be included with the submittal package. Device identification as shown on the control schematics and wiring diagrams shall be referenced in the written Sequence of Operation.
- C. System Architecture: Provide a schematic diagram of the Local Area Network and a controls network architecture diagram indicating supervisory controllers and Graphical User Interface(s). This should be accompanied by explicit information regarding configuration of Routers, Bridges and Repeaters. Each schematic shall have all control points labeled. The schematic shall graphically show all control elements. The point name format shall be approved by the Engineer before any drawing or programming proceeds.

#### 1.13 WARRANTY

- A. The temperature control system contractor shall provide a one (1) year warranty that will commence from the Date of Substantial Completion.
- B. The contractor shall respond during normal business hours to the job site within a 24-hour period for any emergency relating to the control system during the warranty period.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
  - 1. Johnson Controls; no exceptions

#### 2.2 GENERAL

- A. All materials and equipment used shall be standard components, of regular manufacture for this application. All systems and components shall have been thoroughly tested and proven in actual use.
- B. All products used in this project shall be new, currently under manufacture, and shall be applied in similar installations for a minimum of 2 years. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's Representative in writing. Spare parts shall be available for at least 5 years after completion of this contract.

## 2.3 MATERIALS

### A. Wiring and Conduit – Refer to Div. 16.

1. All wire shall be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 volt
Communications Per Mfr. Recommendations		

2. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
3. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
4. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum ½ inch galvanized EMT. Watertight compression fittings shall be used. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
5. Flexible metallic conduit (max. 3 feet) shall be used for connections to controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
6. Junction boxes shall be provided at all cable splices, equipment terminations, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

### B. Damper and Valve Actuators:

1. Control air damper actuators shall be electric, low voltage (24 VAC) utilizing a 4-20 mA modulating control signal as required by the sequence of operation. Each actuator shall incorporate a spring return to position the dampers to their normal positions upon a loss of the 24 VAC control power. Control air damper actuators shall be properly sized to provide sufficient torque to their respective dampers throughout the actuator's operating range. All control air damper actuators shall be mounted outside of the air stream. Provide low leakage controls dampers to prevent air leakage for better pressure control of the zone. Provide fast acting actuators for better smoke purge reaction time.
2. Valve actuators for heating water and chilled water systems shall be electric. Operators shall be sized to operate their appropriate valves with sufficient reserve power to provide smooth modulating action or two position action as specified.

### C. Control Panels: All application specific direct digital controllers, not specifically designed for direct mounting on the equipment served, shall be installed in NEMA 1 enclosures. Enclosures shall be of suitable size to accommodate all power supplies, relays and accessories required for the application. Each enclosure shall include a perforated subpanel for direct mounting on the enclosure devices.

D. Temperature Sensors:

1. Duct/Wall Sensors: As required by the sequence of operation, provide either 1,000 OHM Balco or 10K OHM Thermistor type sensors. Where the element is used for sensing mixed air or coil discharge temperatures and/or the duct cross-sectional area is in excess of 14 square feet, the element shall be of the averaging type. Where temperature elements are used for sensing liquid temperatures, they shall be furnished with separable stainless-steel wells. Cold Deck and Hot Duct temperature sensor product shall be a Johnson Controls TE-6311M-1. Mixed air temperature sensor product shall be a Johnson Controls TE-6316M-1. Discharge air temperature sensors for zone sensors shall be Johnson Controls NS-B8BTN240-0
2. Space Temp/Humidity Sensors: Space temperature/humidity sensors shall be Resistance temperature devices (RTD), or thermistor equipped with set point adjustment, override switch, and communication port. Humidity accuracy shall be 3%. LCD shall be provided for the temperature and the humidity. Product shall be a Johnson Controls NS-B8BTN240-0.
3. Binary Temperature Devices:
  - a. Low-voltage space thermostat shall be 24 V, bimetal-operated, snap action type, with either adjustable or fixed anticipation heater, concealed setpoint adjustment, 55°F to 85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
  - b. Line-voltage space thermostat shall be bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type, or equivalent solid-state type, with heat anticipator, UL listed for electrical rating, concealed setpoint.
  - c. Low-limit thermostats. Low-limit thermostats shall be vapor pressure type with an element 20 ft minimum length. Element shall respond to the lowest temperature sensed by any 1 ft section. The low-limit thermostat shall be manual reset only. Product shall be a Johnson Controls A70HA-1C. This shall be installed on the hot deck and cold deck coils.

E. Analog Current Sensors: As required by the sequence of operation, provide split-core, sensors for indication of equipment amperage. Span shall be adjustable for improved resolution. Current sensors shall incorporate trip indication LED's and shall be sized for proper operation with equipment they serve. Current sensors and installation to be provided under work of this section.

F. Pressure Sensors:

1. Differential pressure type switches shall be UL Listed, SPDT snap acting, pilot duty rated, NEMA 4 enclosure, with scale range and differential suitable for intended applications, or as shown.
2. Differential pressure sensors used for sensing pressure in the ductwork shall be Johnson Controls DPT2641-005D-1 with a FTG18A-600R.
3. As required by the sequence of operation, provide a differential pressure switch across each air handling unit filter section for unit filter alarm indication. Product shall be a Johnson Controls P32AC-2C with a FTG18A-600R.
4. Differential pressure sensors used for high static pressure in duct work shall be a Johnson Control AFS-460 with a FTG18A-600R.

G. Duct Temperature/Humidity Sensor: The temperature and humidity combination sensor shall be used in calculated enthalpy for the economizer function. Product shall have 3% accuracy with a



1k Ohm nickel temperature sensor. Product shall be Johnson Control HE-67N3-0N00P. This device will be installed in the return air and outside air duct work.

- H. Damper Actuators: The damper actuators shall be incremental, non-spring return, with a torque of 35 lb\*in, and a built-in pressure differential transmitter. The damper actuators shall be a Johnson Controls M9104-AGS-2N.

## 2.4 DDC EQUIPMENT

- A. Workstation Client Hardware Stations: The system shall be capable of supporting clients using a standard Web browser such as Internet Explorer™ operating on any standard computer that supports the current version of Internet Explorer™.

- B. Web Browser Clients:

1. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
2. The Web browser client shall support at a minimum, the following functions:
  - a. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
  - b. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
  - c. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
  - d. Storage of the graphical screens shall be in the Building Control Units (BC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
  - e. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
  - f. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
    - 1) Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
    - 2) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
    - 3) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
    - 4) Commands to start and stop binary objects shall be done by right clicking the selected object and selecting the appropriate command from the pop-up menu.
    - 5) View logs and charts.
    - 6) View and acknowledge alarms.

- 7) The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- 8) Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

C. Control Units General:

1. Provide an adequate number of control units to achieve monitoring and control of all data points specified and necessary to satisfy the sequence of operation for all mechanical systems shown on the plans. Provide a minimum of one separate controller for each AHU or other HVAC system. Multiple DDC controllers may control one system provided that all points associated with individual control loops are assigned to the same DDC controller. Points used for control loop reset such as outside air or space temperature are exempt from this requirement. Each of the following panel types shall meet the following requirements.
2. Controllers shall be suitable for the anticipated ambient conditions.
3. Controllers used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosures and shall be rated for operation at -40°F to 140°F and 5 to 95% RH, non-condensing.
4. Controllers used in conditioned ambient space shall be mounted in dust-proof enclosures and shall be rated for operation at 32°F to 122°F and 5 to 95% RH, non-condensing.
5. Serviceability: Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
6. Memory: The Control Units shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
7. Diagnostics: The Building Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall assume a predetermined failure mode and generate an alarm notification.
8. Immunity to power and noise: Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 ft.
9. Automatic staggered restart of field equipment after restoration of power and short cycle protection.

D. Supervisory Network Engine (SNE):

1. The Supervisory Network Engine (SNE) shall provide the interface between the LAN or WAN and the field control devices and provide global supervisory control functions over the control devices connected to the UNC. It shall be capable of executing application control programs to provide:
  - a. Calendar functions
  - b. Scheduling
  - c. Trending
  - d. Alarm monitoring and routing

- e. Time synchronization by means of an Atomic Clock Internet site including automatic synchronization
  - f. Integration data and BACnet controller data
2. The Supervisory Network Engine (SNE) must provide the following hardware features as a minimum:
- a. One Ethernet Port – 10/100 Mbps
  - b. One RS-232 port
  - c. Battery Backup
  - d. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
3. SNE shall provide the capability for multiple user access to the system and support for relational database access (ODBC, SQL or IBM). A database resident on the NAE shall be ODBC compliant database or must be capable of supporting an ODBC data access mechanism to read and write data stored within it.
4. SNE shall provide the capability to support standard Web browser access via the Intranet/Internet. It shall support a minimum of 4 simultaneous users.
5. Event Alarm Notification and Actions:
- a. The SNE shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
  - b. The SNE shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
  - c. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
    - 1) To alarm
    - 2) Return to normal
    - 3) To fault
  - d. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
  - e. Provide timed (schedule) routing of alarms by class, object, group, or node.
  - f. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
  - g. Control equipment and network failures shall be treated as alarms and annunciated.
  - h. Alarms shall be annunciated in any of the following manners as defined by the user.
  - i. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
    - 1) Day of week
    - 2) Time of day
    - 3) Recipient

- j. Pagers via paging services that initiate a page on receipt of email message.
- k. The following shall be recorded by the SNE for each alarm (at a minimum):
  - 1) Time and date
  - 2) Location (building, floor, zone, office number, etc.)
  - 3) Equipment (air handler #, accessway, etc.)
  - 4) Acknowledge time, date, and user who issued acknowledgement.
  - 5) Number of occurrences since last acknowledgement.
- l. Alarm actions may be initiated by user defined programmable objects created for that purpose.
- m. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
- n. Provide a “query” feature to allow review of specific alarms by user defined parameters.
- o. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
- p. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

E. General Purpose Application Controllers (CGM04060 & CGM09090):

- 1. Standalone DDC panels shall be microprocessor-based, multi-tasking, multi-user, real-time digital control processors. Each standalone DDC panel shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, and input/output modules. A sufficient number of controllers shall be supplied to fully meet the requirements of this Specification and the attached point list.
- 2. Hardware Overrides – As indicated in the point schedule, the operator shall have the ability to manually override automatic or centrally execute commands.
- 3. Hardware Override Monitoring – DDC panels shall monitor the status or position of all overrides and include this information in logs and summaries to inform the operator that automatic control has been inhibited. DDC panels shall also collect override activity information for daily and monthly reports.
- 4. Sensor Support:
  - a. The controller shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network sensor.
  - b. The Network Sensor shall support an LCD display room sensor.

## PART 3 - EXECUTION

### 3.1 INSTALLATION AND WORKSMANSHIP

- A. Install equipment, piping and wiring raceway parallel to the building lines (i.e., horizontal, vertical and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

- C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electric Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation and wiring shall comply with acceptable industry specifications and standards for performance, reliability and compatibility and be executed in strict adherence to local codes and standard practices.

### 3.2 ELECTRICAL INTERLOCKS

- A. All electrical interlocks shall be provided as specified. All electrical interlocks shall be made by means of motor starters or shall be accomplished by separate relays. No motor power lead shall be utilized in an interlock circuit. All interlocked starters with disconnect switches shall be provided with auxiliary contacts on the disconnect switch so that interlocking circuits are interrupted when the disconnect switch is in the off position.

### 3.3 OWNERSHIP OF PROPRIETARY MATERIAL

- A. The owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to owner as defined by the manufacturer's license agreement but shall protect manufacturer's rights to disclosure of trade secrets contained within such software. All project developed software and documentation shall become the property of the owner. These include, but are not limited to project graphic images, record drawings, project database, project specific application programming code, and all other associated documentation.

### 3.4 TRAINING

- A. Provide a minimum of 8 hours of on-site training throughout the contract period for personnel designated by the Owner. Train the designated staff of Owners Representative and Owner to enable them to:
  - 1. Proficiently operate the system.
  - 2. Understand control system architecture and configuration.
  - 3. Understand DDC system components.
  - 4. Understand system operation, including DDC system control and optimizing routines (algorithms).
  - 5. Operate the workstation and peripherals.
  - 6. Log on and off the system.
  - 7. Access graphics, point reports, and logs.
  - 8. Adjust and change system set points, time schedules, and holiday schedules.
  - 9. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals.
  - 10. Understand system drawings, and Operation and Maintenance manual.
  - 11. Understand the job layout and location of control components.
  - 12. Access data from DDC controller.
  - 13. Operate portable operator's terminals.

PART 4 – SEQUENCE OF OPERATIONS – Provide color graphics at the OWS to show all functions and monitoring points on a graphic for each of the systems below.

4.1 CHILLERS (2)

- A. Fully integrate the Chiller microprocessor controls (VIA BACnet) into the building automation system. Provide all available diagnostic, monitoring and alarm points provided by the chiller manufacturer, and transmit to the chiller microprocessor the following commands: Start/Stop, chilled water setpoint.

4.2 PUMPS (2)

- A. Provide start/stop, positive indication of run status for each pump provided. Interlock the chilled water pumps with the chillers so that the chiller cannot run until the pump operation is verified. Provide Variable Frequency Drives as specified for each pump. The purpose of the VFDs is to vary the speed of the pump to maintain pressure as sensed in the chase at the top of the riser.

4.3 MAKE UP AIR UNITS (DOAS) (2)

- A. BACnet INTERFACE: Provide BACnet MS/TP communication to Make-Up Air Units. Discover BACnet objects and provide data for Make-Up Air Units. The units shall be enabled to run to deliver filtered, dehumidified, neutral air to each intake location at the roof.

END OF SECTION 15900

## SECTION 16010 – BASIC ELECTRICAL REQUIREMENTS

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SCOPE

- A. The work included in Division 16 of the Specifications includes all electrical work, interior and exterior to the project. Provide all materials, labor, equipment, transportation, tools, permits, fees, and supervision to install, test and make operational the complete electrical systems.

#### 1.3 QUALITY ASSURANCE

- A. Referenced Standards: Provide and install products in accordance with referenced standards. Comply with the standards listed in each section.
- B. Codes: The electrical work shall be in accordance with latest edition of the following codes:
  - 1. National Electrical Code
  - 2. National Electrical Safety Code
  - 3. Life Safety Code
  - 4. International Building Code
  - 5. City of Paris Electrical Ordinance
  - 6. State of Texas codes as applicable
  - 7. National Fire Protection Association
  - 8. Other codes as referenced in individual sections
- C. Material Standards: Materials and equipment shall be listed or labeled as defined in Article 100 of the National Electrical Code (NEC), by a testing agency acceptable to the Owner. Materials shall be marked for their intended use.
- D. Permits and Inspections: Obtain all permits and inspections for the installation of the work and pay all charges incident thereto. Deliver to the Owner all certificates of inspections issued by authorities having jurisdiction.

#### 1.4 SUBMITTALS

- A. Provide submittals for equipment as listed in each Section.
- B. Submittals shall include descriptive material, catalog sheets, diagrams, performance curves, and charts published by the manufacturer to show conformance with drawings and specifications.
- C. Provide complete electrical characteristics for all equipment. Lighting submittals shall include photometric data.
- D. Submittals shall be clearly marked showing the individual item offered.

- E. All electrical submittals shall be bound in a book, indexed by specification section, and certified that they have been checked by the contractor.
- F. Omissions from the submittal of any material which has been shown on the drawings or specified, does not relieve the contractor from furnishing and installing the item.

## 1.5 WARRANTY

- A. The contractor warrants the material and equipment installed to be free from defects for a period of one year after acceptance by the owner. All defects in labor or materials occurring during this period shall be repaired or replaced.

## PART 2 - PRODUCTS

### 2.1 EQUIPMENT REQUIREMENTS

- A. The electrical equipment specified and shown on the drawings is based on information available at the time of design. If the equipment furnished has different electrical requirements, the contractor shall make the required changes to the wire, conduit, controls, overcurrent protection, switchgear, and installation as required to accommodate the equipment supplied, without additional charge to the owner. The cost for such adjustments shall be assigned to the respective section of this Specification under which the equipment is furnished.

### 2.2 MATERIALS

- A. All materials shall be UL labeled where a Standard exists for the product. If the product does not bear the UL label, the manufacturer shall submit documentation from an independent testing laboratory, acceptable to the authority having jurisdiction, showing evidence that the product is suitable for the installation.
- B. Materials and equipment shall be the standard products in current production of manufacturers regularly engaged in the production of such equipment.
- C. All materials shall be new and free from defects. Materials of the same type shall be the product of one manufacturer.
- D. All material and equipment shall be installed, applied, and handled in accordance with the manufacturer's recommendations and standards.
- E. Where no specific material is mentioned, provide the required material from a reputable manufacturer. The material shall conform to the project requirements, and shall be suitable to the engineer.

## PART 3 - EXECUTION

### 3.1 GENERAL

- A. Fabricate, erect, and install the complete electrical systems in accordance with accepted good practice by qualified personnel who are licensed and experienced in such work. Proceed in an orderly manner so as not to impede the progress of the project.



### 3.2 DRAWINGS

- A. The electrical drawings are diagrammatic. Carefully coordinate the work with structural, architectural, and mechanical conditions. Make adjustments to avoid conflicts.
- B. The locations shown for electrical equipment is approximate and not intended to convey the exact details of installation. Exact locations are to be determined in the field by actual measurements.
- C. The contractor is responsible for fitting the equipment and material into the space. If the equipment furnished requires different space conditions than shown on the drawings, the contractor shall arrange for such space and shall submit a drawing indicating the exact details of installation prior to construction.
- D. Do not scale drawings. Layout electrical equipment using dimensions obtained from the manufacturer of the equipment and from field measurements.

### 3.3 SITE INVESTIGATION

- A. Prior to submitting bids, visit the site and become aware of existing conditions that may affect the cost of the project. Include in the bid the work required to remove, extend, relocate, reconnect or modify existing equipment or systems, and to restore them to their original condition.

### 3.4 MATERIALS HANDLING AND STORAGE

- A. Handle materials in accordance with the manufacturer's standards and recommendations.
- B. All materials, except those specifically designed to be installed outdoors, shall be stored in an enclosed, dry building or trailer. Protect all stored equipment from damage. Remove damaged materials from the premises.
- C. Equipment and materials shall not be installed until such time as the environmental conditions of the job site are suitable to protect the equipment and materials. They shall be protected from water, direct sunlight, cold and heat unless designed for such conditions.

### 3.5 CUTTING AND PATCHING

- A. Sleeve or cut all openings in walls, floors, ceilings and roof required to install the electrical work.
- B. Do not cut structural members unless specific permission is granted by the structural engineer.
- C. Patch all openings after installation of the work, and repair any damage caused by this activity. Restore the surface to its original condition.

### 3.6 PAINTING

- A. Refer to PAINTING Section of these Specifications.
- B. Touchup scratched or marred surfaces of all electrical equipment with paint obtained from the equipment manufacturers specifically for that purpose. Remove all oil, dirt, grease and foreign material before painting and prepare the surface as recommended by the manufacturer.

- C. Where plywood backboards are used to mount equipment, paint backboards with two coats of light gray semi-gloss paint.

### 3.7 TESTING

- A. Provide all field-testing specified in the individual specification sections.

### 3.8 RECORD DOCUMENTS

- A. Provide record documents as required in Division 1 of the specifications.

### 3.9 OPERATION AND MAINTENANCE INSTRUCTIONS

- A. Provide Operation and Maintenance manuals as required in Division 1 of the specifications.
- B. Before final inspection, instruct the owner's personnel in operation of the systems under this Division. Use the Operation and Maintenance Manual as basis for the instruction. Review the contents of the manual in detail and explain all aspects of operation and maintenance.
- C. Prepare and insert additional data in the manual when need for such data becomes apparent during instruction.

END OF SECTION 16010

## SECTION 16110 – RACEWAYS

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit product data sheets for all conduits and fittings.

#### 1.3 SCOPE

- A. Furnish and install all conduits, wireways, raceways, and fittings for all systems interior and exterior to the building.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards: Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. American National Standards Institute (ANSI)  
C-80.1 Rigid Galvanized Conduit  
C-80.3 Electrical Metallic Tubing
  - 3. Underwriters Laboratories, Inc. (UL)  
UL 1 Flexible Metal Conduit  
UL 5 Surface Metal Raceways and Fittings  
UL 6 Rigid Metal Conduit  
UL 651 Rigid PVC Conduit  
UL 797 Electrical Metallic Tubing  
UL 1242 Intermediate Metal Conduit  
UL 360 Liquid-Tight Flexible Steel Conduit
  - 4. National Electrical Manufacturers Association (NEMA)  
RN1 Externally PVC Coated GRS and IMC Conduit

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable:
  - 1. Metal Conduit and Fittings:
    - a. Allied

- b. Wheatland
  - c. Appleton
  - d. Raco
  - e. Killark
  - f. O-Z / Gedney
- 2. PVC Conduit and Fittings:
  - a. Carlon
  - b. Certainteed
- 3. PVC Coated Metal Conduit: Robroy Industries

## 2.2 METAL CONDUIT AND FITTINGS

- A. Rigid Steel Conduit (GRS):
  - 1. Rigid, threaded, galvanized inside and outside or galvanized outside with protective coating inside.
  - 2. Factory made steel threaded couplings.
- B. Intermediate Metal Conduit (IMC):
  - 1. Rigid, threaded, thin wall steel, galvanized outside with protective coating inside.
  - 2. Factory made steel threaded couplings.
- C. Electrical Metallic Tubing (EMT):
  - 1. Steel tubing, galvanized outside with slick corrosion resistant interior coating.
  - 2. Steel compression couplings and box connectors.
- D. Flexible Metal Conduit:
  - 1. Spirally wound with interlocking galvanized steel strips. Aluminum is not permitted.
  - 2. Flexible conduit shall be approved for use as equipment grounding conductor.
  - 3. Connectors shall be steel, suitable for grounding continuity.
- E. Liquidtight Flexible Metal Conduit:
  - 1. Spirally wound with interlocking galvanized steel strips with PVC cover extruded over the exterior to make the conduit liquidtight.
  - 2. Shall be approved for use as equipment grounding conductor.
  - 3. Shall be steel, suitable for grounding continuity, liquidtight.

## 2.3 PVC CONDUIT AND FITTINGS

- A. PVC conduit shall be Schedule 40 unless noted otherwise.
- B. Exterior underground conduit encased in concrete ductbank shall be type EB.
- C. Conduit fittings shall be the same material as the conduit supplied by the same manufacturer.

## 2.4 PVC COATED METAL CONDUIT AND FITTINGS

- A. The PVC coated rigid galvanized steel conduit must be UL Listed. The PVC coated conduit shall be hot dip galvanized inside and out. The PVC coated conduit factory-cut threads shall be protected with hot galvanized threads and a clear urethane coating. Thread protectors shall be used on the exposed threads of the PVC coated conduit. The PVC coating must have been investigated by UL as providing the primary corrosion protection for the rigid galvanized steel conduit. The PVC coating shall be gray, 40 mils in thickness, continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles, or pinholes. Applicable UL standards may include: UL 6 Standard for Safety, Rigid Metal Conduit.
- B. The PVC coated rigid galvanized steel conduit must be certified and authorized to apply the ETL Verification Mark "ETL Verified to PVC-001". ETL Verified to: Intertek ETL SEMKO High Temperature H20 PVC Coating Adhesion Test Procedure.
- C. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to PVC coating must be UL listed. The PVC coating shall be gray, 40 mils in thickness, and be free of blisters, bubbles, or pinholes. Applicable UL standards may include: UL514B Standard for Safety, Fittings for Conduit and Outlet Boxes; UL 886 Standard for Safety for Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.
- D. Form 8 conduit bodies, 1/2" through 2" diameters, shall have a tongue-in-groove, V-Seal gasket to effectively seal against corrosive elements, and be supplied with plastic encapsulated stainless steel cover screws.
- E. A PVC sealing sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening, except unions. The inside sealing sleeve diameter shall be matched to the outside diameter of the conduit.
- F. The PVC coating on the outside of conduit couplings shall be 40 mils in thickness and have a series of raised longitudinal ribs to protect the coating from tool damage during installation.
- G. A red, green, or gray urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2-mil thickness. Conduit or fittings having pinholes or areas with thin or no coating shall be unacceptable.
- H. All male threads on elbows and nipples, and female threads on fittings or conduit couplings shall be protected by application of a red, green, or gray urethane coating.
- I. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the PVC coated conduit.
- J. Independent certified test results shall be available to confirm coating adhesion under the following conditions:
- K. The exterior coating bond shall be confirmed using the methods described in Section 3.8, NEMA RN1. After these tests the physical properties of the exterior coating shall exceed the minimum requirements specified in Table 3.1, NEMA RN1.

- L. Installation of the PVC coated conduit system shall be performed in accordance with the manufacturer's installation manual. PVC coated conduit installers shall be certified by the PVC coated conduit manufacturer before the installation can begin.
- M. All PVC coated conduit, fittings, and accessories must be new, unused material.
- N. All PVC coated conduit, fittings, and accessories shall be supplied by the same manufacturer.
- O. Material brands of PVC coated conduit systems known to meet the above specifications:
  - 1. Plasti-Bond
  - 2. Perma-Cote
  - 3. KorKap

## PART 3 – EXECUTION

### 3.1 INSTALLATION OF BUILDING RACEWAYS

- A. All wiring of every description shall be run in conduit or electrical metallic tubing unless noted or specified otherwise. Conduits may be run exposed in machinery and electrical rooms and unfinished areas. All other conduits shall be run concealed unless otherwise noted. All exposed runs shall be installed parallel to the surface of the building in a neat and orderly manner.
- B. Types: All conduits installed in wet or damp locations, or on roofs shall be rigid galvanized steel conduits. Above grade interior conduits shall be rigid galvanized steel conduit, intermediate metal conduits or electrical metallic tubing. Conduits installed below grade in slabs or buried in earth shall be PVC or PVC coated rigid galvanized steel or wrapped rigid galvanized steel.
- C. Sizes: Size and install raceways so that conductors may be drawn in without injury or excessive strain. Make field bends with approved bending devices. Do not install bends or offsets in which conduit is crushed, deformed or otherwise injured.
- D. Connections: Use lengths of flexible metal conduit, not less than 12" long at final connections to all motors, generators, controls and other devices subject to movement because of vibration or mechanical adjustment. Use flexible metal conduit also at connections to recessed lighting fixtures, and elsewhere as required. In damp or wet locations, and where installed outdoors, use liquidtight flexible metal conduit.
- E. Around Heat Producing Equipment: Do not install raceways within 3" of steam and hot water pipes, breeching and flues, except where crossings are unavoidable, and then keep raceways at least 1" from insulation on the pipe, breeching or flue crossed. Wherever possible, avoid installing raceways directly above or in close proximity to boilers and other like objects operating at high temperatures.
- F. Damp or Wet Locations: In damp or wet locations make every effort to avoid installing raceways in a manner which will create moisture traps. Where they must be so installed, seal both ends of raceways with an approved sealing compound to prevent "breathing" and moisture condensation within the raceways.
- G. Different Systems: In systems operating at more than 300 volts between phase conductors, where different phase conductors are to be run to a common gang wall switch box, install a separate

conduit for each different phase wire and its return switch leg, and provide substantial barriers between adjacent switches in the box so that two different phase wires will not be the same compartment.

- H. Joining Rigid Conduits: Join with threaded couplings. Ream out all conduit ends after threading. Secure rigid conduits at panel boxes, junction boxes, pull boxes, switchboards, support boxes, or sheet metal outlet boxes by galvanized locknuts, inside and outside, with insulating bushing inside. Unthreaded set screw type couplings or connectors are not acceptable in rigid conduit systems. No running threads shall be used anywhere in conduit systems.
- I. Protection of Raceways: Seal ends of all raceways with blank discs ("pennies"), push pennies or other approved closers during construction. Do not pull any conductors into raceways until all plastering in the vicinity is completed. Swab out all raceways before pulling in conductors.
- J. Penetrations: Wherever raceways pass through floors, walls partitions, etc., carefully fill any space between the outside of the raceway and the building material to prevent passage of air, water, smoke and fumes. Filling material shall be fire-resistive and installed to meet requirements of the UL Fire Resistance Directory.

### 3.2 CONDUIT SUPPORTS

- A. Support Spacing: Use minimum spacing as directed by National Electrical Code, but space hangers more closely where required by conditions.
- B. Vertical Conduit Risers: Support vertical conduits at each floor by means of riser clamps or U-bolts, clamping them to a steel channel bridging the opening in the floor.
- C. Individual Conduits: Support conduits running vertically or horizontally with galvanized malleable iron one hole clamps. Carry individually supported horizontal conduits 1-1/4" and larger on Kindorf No. 150 or Steel City No. C-149 hangers. Use no perforated strap iron as hanger material. Where conduits smaller than 1-1/4" are installed above metal lath and plaster ceilings or mechanically suspended dry ceilings of the non-removable type, they may be supported on ceiling runner channels. Where conduits smaller than 1-1/4" are installed above removable ceilings, attach them to the structure or bar joists (where present) or support them on threaded hanger rods with clips. Do not use any wire to support conduits or to attach conduits to supporting members. Locate conduits a sufficient distance above the ceiling to permit removal of the ceiling panels. Locate them so as not to hinder access to mechanical and electrical equipment through the ceiling panels.
- D. Multiple Conduits: Where multiple raceways are run horizontally at the same elevations, they may be supported on trapezes formed of sections of Unistrut angle iron or channels suspended on rods or pipes. Size trapeze members including the suspension rods for the number size and loaded weight of the conduits they are to support. Space them as required for the smallest conduit supported.

END OF SECTION 16110

## SECTION 16120 – WIRES AND CABLES

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit catalog data sheets on all conductors and cables and wire.

#### 1.3 SCOPE

- A. Under this Section, furnish and install all building wires and cables (600 volts and below) complete with connectors and terminations. Exterior branch circuits and feeders are also included in this section. Wiring for communication and alarm systems are included in their respective sections unless they reference this Section.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards. Provide products which comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. Underwriters Laboratories, Inc. (U.L.)
    - UL 44 Thermoset-Insulated Wires and Cables
    - UL 83 Thermoplastic-Insulated Wires and Cables
    - UL 486 Wire Connectors and Soldering Lugs
    - UL 510 Insulating Tape

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable.
  - 1. Insulated Cable:
    - a. Southwire Co.
    - b. Senator Wire & Cable Co.
    - c. Okonite
    - d. Anaconda
    - e. Pirelli Cable Co.



2. Electrical Spring Connectors:

- a. Scotch
- b. Ideal
- c. Buchanan

3. Compression Connectors:

- a. Burndy
- b. Scotch
- c. IlSCO

4. Mechanical Connectors:

- a. Burndy
- b. Scotch
- c. Ideal

5. Insulating Kits:

- a. Raychem
- b. Scotch

6. Insulating Tape: Scotch

2.2 CONDUCTORS

- A. Type: Soft drawn copper, UL listed, rated at 600 volts, free from flaws and imperfections. Conductors no. 10 and smaller shall be solid. Conductors larger than no. 10 shall be stranded.
- B. Insulation: Unless otherwise indicated on the drawings, otherwise specified in other Sections, or otherwise required by the National Electrical Code, conductors shall have type THHN/THWN or XHHW insulation.
- C. High Temperatures: Use type RHH or RHW-2 for wiring in proximity to boilers and other devices subject to high temperatures.
- D. Markings: Conductors shall be marked on the surface with rated voltage, size, type, and manufacturer. The size shall be repeated at intervals not exceeding 24 inches, with the remaining data repeated at intervals not exceeding 40 inches.
- E. Performance: Conductors shall be electrically continuous and free from shorts or grounds. All open or shorted conductors shall be replaced. All conductors with damaged insulation shall be removed and replaced with new conductors free from defects.
- F. Conductors and cables installed open in ceiling plenums shall be plenum-rated.

2.3 JOINTS AND SPLICES

- A. Solid Conductors (No. 10 AWG and smaller): U.L. approved, screw-on, electrical spring connectors, 600 volt, 105C, insulated.

- B. Stranded Conductors (No. 8 and Larger): Crimp type compression connectors properly selected for the conductor size and material. All connectors shall be applied with properly sized dies and tools as recommended by the manufacturer. Insulate the splice with an insulating kit providing 600 volt, 90C rating.

## 2.4 COLOR CODING

### A. Equipment Grounding Conductors:

1. Equipment grounding conductors shall be green. Grounding conductors from isolated grounding system shall be green with yellow stripes.
2. Equipment grounding conductors, no. 6 awg and smaller shall have continuous color-coding the entire length of the conductor. Sizes larger than no. 6 awg shall be permitted to be identified at each end, and at every point where the conductor is accessible. The marking shall consist of green tape, or green adhesive labels.

### B. Neutral Conductors:

1. Neutral conductors shall be white or natural gray.
2. Where systems of different voltages are installed, the neutral of the lower voltage shall be white or natural gray, and the neutral of the higher voltage shall have three continuous white stripes on other than green insulation.
3. Sizes no. 6 awg, or smaller shall have continuous color-coding the entire length of the conductor. Larger sizes shall be permitted to be identified at each end, and at every point where the conductor is accessible. The marking shall consist of white tape or stripped tape or white adhesive labels.

### C. Phase Conductors:

1. Conductors no. 10 awg and smaller shall have continuous color-coding the entire length of the conductor. Larger sizes shall be permitted to be identified at each end, and at every point where the conductor is accessible. The marking shall consist of colored tape, or colored adhesive labels.
2. The color-coding system employed shall be permanently posted on the inside door of each branch-circuit panelboard. The posting shall identify the color-coding of each phase conductor and shall be applied to the inside of the door with adhesive.
3. 120/208 volt, 3 phase system:
  - Phase A – Black
  - Phase B – Red
  - Phase C – Blue
4. 277/480 volt, three phase system:
  - Phase A – Yellow
  - Phase B – Brown
  - Phase C – Orange

## PART 3 – EXECUTION

### 3.1 INSTALLATION OF WIRING

- A. Install all wiring in raceways unless specified otherwise.

- B. Wire Pulling: Provide suitable installation equipment for pulling conductors into raceways or conduits. Use ropes of polyethylene, nylon or other suitable material to pull in conductors. Attach pulling lines to conductors by means of woven basket grips or by pulling eyes attached directly to conductors. All conductors to be installed in a single conduit shall be pulled in together. Use U.L. listed cable pulling compound where necessary.
- C. Cable Lubricants: All cable lubricants shall be UL listed, and shall be certified by their manufacturer to be non-injurious to the insulation on which they are used.
- D. Wire Sizing:
1. No wire shall be smaller than no. 12, except for signal and control circuits, or lighting fixture taps.
  2. Receptacle and motor branch circuits – Use no. 12 conductors unless noted or scheduled otherwise.
  3. 120 volt, 20 amp lighting and receptacle branch circuits – Where the length of run from panelboard to first lighting outlet or receptacle exceeds 85 feet use no. 10 conductors; otherwise use no. 12.
  4. 277 volt, 20 amp lighting branch circuit – Where the length of run from panelboard to first lighting outlet exceeds 175 feet, use no. 10 conductors; otherwise use no. 12.
  5. Where more than three current-carrying conductors are installed in the same conduit or raceway, the conductors shall be increased in size as required to maintain the required ampacity after application of the adjustment factors of NEC Table 310-15(b)(2)(a).
  6. All branch circuit wiring connected to the load side of dimmers shall have an individual neutral installed with each circuit.
- E. Joints and Splices:
1. Make joints and splices only where necessary and only at outlet boxes, wiring troughs and other enclosures permitted by the NEC. All joints shall be mechanically and electrically secure.
  2. Do not splice conductors in panelboards, safety switches, switchboards, motor control centers or motor control enclosures.
  3. Conductors for use with insulated spring connectors shall be twisted together prior to application of the connector.
- F. Terminations: Tighten electrical connections and terminations in accordance with the manufacturer's published values. A calibrated tool shall be used to insure proper torque values.
- G. Bundling: Bundle all conductors in panelboards, cabinets, pullboxes and the like using nylon straps made for this purpose. Bundle conductors larger than no. 10 in individual circuits. Bundle smaller conductors in larger groups.
- H. Identification: Refer to ELECTRICAL IDENTIFICATION SECTION.
1. Mark conductors to clearly identify each circuit by number. Securely attach to each conductor in each junction box, pull box, panelboard, etc.
  2. The cover of each junction box and pullbox shall be marked with the designations of each circuit contained therein.
  3. Where colored plastic tape is applied to conductors for identification, use half-lapped turns for a distance of 6 inches from the terminal points and in boxes where taps and splices are

made. Apply the last two turns with no tension to prevent unwinding. Use 1-inch wide tape applied to avoid obscuring cable identification markings.

### 3.2 FIELD TESTING

- A. Tests and procedures shall be in accordance with the applicable IPCEA standards. Furnish all instruments, equipment and personnel required for testing. Submit test data to the engineer on data sheets in a format that can be compared with future testing. All test data shall be included in the project operating manual.
- B. Test wires and cables for electrical continuity and short circuits.
- C. Prior to terminating, check each service and feeder conductor with megohmmeter to determine the insulation resistance with respect to ground and other phases. Applied potential shall be 1000 volts dc for 1 minute.
- D. Test cable mechanical connections to the manufacturer's recommended values using calibrated torque wrench.
- E. Energize circuits and demonstrate proper operation.

END OF SECTION 16120

## SECTION 16130 – BOXES

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit catalog data sheets for all boxes.

#### 1.3 SCOPE

- A. Furnish and install electrical boxes in accordance with the requirements of the National Electrical Code.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards. Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. Underwriters Laboratories, Inc. (UL)  
No. 514 Outlet boxes and fittings  
No. 50 Enclosures for Electrical Equipment
  - 3. National Electrical Manufacturers Association (NEMA)  
No. OS 1 Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports  
No. FB 1 Fittings and Supports for Conduit and Cable Assemblies

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable.
  - 1. Sheet Steel Outlet and Device Boxes:
    - a. Raco
    - b. Steel City
    - c. Appleton
  - 2. Cast Metal Device Boxes:
    - a. Crouse Hinds
    - b. Appleton

c. Pyle National

2.2 OUTLET AND DEVICE BOXES

- A. All boxes shall be UL listed.
- B. Sheet steel boxes shall be not lighter than 14 gauge, galvanized after fabrication.
- C. Cast metal boxes shall be cast iron or cast alloy.
- D. Outlet boxes for switches, receptacles and communications use shall be 4" square with proper square cornered tile wall cover, plaster cover or finishing plate, except where construction will not permit or the device requires a larger box. Box depth shall be as required by NEC for device and wiring volume requirements, but not smaller than 1-1/2 inches.
- E. Boxes for devices mounted flush in concrete block walls shall be single gang masonry boxes, 3-1/2" deep.
- F. Boxes installed in poured concrete shall be concrete-tight type.
- G. Boxes for surface mounted or pendant fixtures shall be 4" octagonal by 1-1/2" minimum depth.
- H. Boxes for flush mounted fixtures shall be 4" by 4" size with cover installed above the ceiling and accessible by removing ceiling panel or fixture. Connection to fixture shall be with flexible conduit.
- I. Boxes for interior exposed work shall be cast metal boxes (Cast iron or cast alloy).
- J. Boxes for outdoors shall be cast metal boxes with gasketed covers.

2.3 PULLBOXES AND JUNCTION BOXES

- A. Sheet steel galvanized inside and outside, with galvanized covers.
- B. Dimensions shall be as required by NEC for the number, size and locations of conduits entering the box.
- C. Boxes installed above ceilings shall be accessible by removing ceiling panels, installing access door in hard ceiling, or flush mounting the cover on the ceiling.
- D. Boxes installed flush in walls in finished areas shall have overlapping trim with hinged door and lock to match the appearance of electrical panelboard.
- E. All boxes shall have covers.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Provide at each outlet or device of whatever character a metal outlet box in which conduits shall terminate.

- B. All pull and junction boxes shall be accessible after construction is complete. Install access panels in the construction as required to make the box accessible.
- C. Fasten all boxes securely to the building construction, independent of conduit systems.
- D. Where outlet box on grid ceiling supports surface or suspended fixture, provide box with fixture stud and secure the box to ceiling members with steel channel.
- E. Outlet boxes for devices shown back to back shall be offset a minimum of 6 inches.
- F. All boxes shall have covers and unused conduit openings shall be covered.

END OF SECTION 16130

## SECTION 16140 – WIRING DEVICES

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit product data sheets for all wiring devices.

#### 1.3 SCOPE

- A. Furnish and install in suitable outlet boxes, the wiring devices indicated complete with coverplates. All shall be properly connected to conductors so as to be operable.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards: Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. National Electrical Manufacturers Association (NEMA)  
WD 1 General Requirements for Wiring Devices  
WD 6 Wiring Devices – Dimensional requirements
  - 3. Underwriters Laboratories (UL)  
UL 20 General-Use Snap Switches

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable:
  - 1. Hubbell
  - 2. Leviton
  - 3. Pass & Seymour
  - 4. General Electric
  - 5. Bryant

#### 2.2 CLASSIFICATION

- A. All wiring devices shall be UL listed.
- B. All wiring devices shall be specification grade.



## 2.3 COLORS

- A. All devices shall have **white** finish where mounted in walls finished in light colors and a brown finish where mounted in walls finished in dark colors.
- B. All devices connected to the emergency power system shall be **red**.

## 2.4 SWITCHES

- A. The catalog numbers listed are of Hubbell manufacture. Equivalent devices from listed manufacturers are acceptable. Furnish switches in colors specified above even though the numbers listed may not contain the correct suffix.

- |                                    |                                     |
|------------------------------------|-------------------------------------|
| 1. Single pole wall switch – 1221. | 4. Pilot-lighted switch – 1221-PLC. |
| 2. Three-way wall switch – 1223.   | 5. Momentary contact switch – 1556. |
| 3. Four-way wall switch – 1224.    |                                     |

## 2.5 RECEPTACLES

- A. The catalog numbers listed are of Hubbell manufacture. Equivalent devices from listed manufacturers are acceptable. Furnish receptacles in colors specified even though the numbers listed may not contain the correct suffix.

- 1. Duplex receptacle: 20 amp, 125 volt, grounding (NEMA 5-20R) – No. 5362.
- 2. Ground Fault Interrupter Receptacle (GFI) – No. GF-5362.
- 3. Special Receptacles: Furnish devices in the NEMA configuration listed on the drawings.

## 2.6 WEATHERPROOF DEVICES

- A. Provide the specified device in weatherproof cast box with gasketed coverplate.

## 2.7 COVERPLATES

- A. Provide coverplates for all wiring devices, including telephone, signal outlets and other devices. Coverplates shall be one piece single or multi-gang type as required.
- B. Indoor Flush Devices:
  - 1. High impact plastic plates matching the color of the device covered.
  - 2. Where installed in masonry walls, use jumbo plates.
- C. Indoor Surface Devices: For indoor devices use zinc-coated metal with rounded or beveled edges, same size as the box.
- D. Outdoor devices: TayMac

## PART 3 – EXECUTION

### 3.1 INSTALLATION

- A. Install wiring devices plumb and level.

- B. Install SPST wall switches with OFF position down.
- C. Wall switches shall be installed on the strike side of the door as finally hung.
- D. Install receptacles with grounding pole on top.
- E. Install devices within outlet boxes to allow coverplates to be in full contact with the wall on all sides.
- F. After connection of each wiring device, install two full wraps of electrical insulating tape around the side terminals prior to installation in the box.
- G. Replace broken devices and plates with new.
- H. Clean all paint, plaster and dirt from wiring devices and plates.

### 3.2 MOUNTING HEIGHTS

- A. Where mounting heights are indicated on the drawings, the device shall be installed with the centerline of the device at the indicated height.
- B. Devices noted to be installed above counters or millwork shall be installed above the backsplash.
- C. Unless otherwise noted on the drawings, or directed by architect, install devices at the following heights above finished floor:

DEVICE	MOUNTING HEIGHT
Wall switch	46"
Receptacle	18"

### 3.3 IDENTIFICATION

- A. At each wiring device mark the inside of the coverplate with the panel and circuit number to which the device is finally connected. Use black indelible marker.

### 3.4 FIELD TESTING

- A. Energize lighting circuits and operate each wall switch to verify proper operation.
- B. Energize receptacle circuits and test each receptacle with circuit tester to verify the device is energized and has correct polarity.
- C. Test TRIP and RESET buttons on GFI receptacles. In addition, test GFI receptacles with a GFI tester to verify it trips at 4ma of ground current.

END OF SECTION 16140

## SECTION 16170 – GROUNDING AND BONDING

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit product data sheets for all grounding equipment.

#### 1.3 SCOPE

- A. Furnish and install grounding equipment and systems as specified herein. Also refer to, and comply with specific grounding requirements contained in other Sections.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards: Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. Institute of Electrical and Electronic Engineers (IEEE)  
Standard 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth  
Surface Potentials of a Ground System
  - 3. Underwriters Laboratories, Inc. (UL)  
UL 467 Grounding and Bonding Equipment

### PART 2 – PRODUCTS

#### 2.1 MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable:
  - 1. Grounding Products: Chance / Hubbell  
Copperweld Corp  
Erico Inc.  
Ideal Industries, Inc.  
ILSCO  
Kearney / Cooper Power Systems  
Superior Grounding Systems, Inc.  
Thomas and Betts  
Raco, Inc.  
Burndy

## 2.2 CONDUCTORS

### A. Equipment Grounding Conductors:

1. Use insulated conductors that comply with WIRES AND CABLES Section.
2. Equipment grounding conductors shall be green.
3. Isolated ground conductors shall be green with yellow stripes.
4. No. 6 AWG and smaller shall have continuous color-coding the entire length of conductor. Larger sizes shall be identified with color-coded plastic tape at each end, and at every point where the conductor is accessible. For equipment grounding conductors use green tape. For isolated ground conductors use alternating bands of green and yellow tape with a minimum of three bands of green and two bands of yellow.

### B. Grounding Electrode Conductors: Insulated stranded cable complying with WIRES AND CABLES Section.

### C. Underground Ground Conductors: Bare conductors installed underground shall be tinned, stranded complying with ASTM B8.

### D. Bonding Conductors:

1. Bonding cable: 28 kcmil, 14 strands of no. 17 AWG, copper.
2. Bonding Conductor: Bare stranded copper.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors terminated with copper ferrules.

## 2.3 GROUND RODS

### A. Ground rods shall be one-piece or sectional type, copper-clad steel, 5/8" in diameter by 10 feet long.

## 2.4 GROUND CONNECTORS

### A. Compression Connectors:

1. Suitable for direct burial, embedded in concrete, or above grade applications, equal to Burndy Hyground.
2. Connectors shall be equivalent in current-carrying capacity to the maximum size copper conductors being joined.
3. Equipment shall be in accordance with the connector manufacturers recommendation. This shall include cable preparation, installation tools and dies, and the required number of crimps.

### B. Bolted Connectors:

1. UL listed for grounding.
2. Above grade applications.
3. Provide equipment in accordance with connector manufacturers' recommendations for the application.

C. Welded Connectors:

1. Exothermic-welded type, UL listed for grounding connections.
2. Provided in kit form and selected for the specific types, sizes, conductors and other items to be connected.

## PART 3 – EXECUTION

### 3.1 SERVICE GROUNDING

- A. Provide adequate and permanent service neutral and equipment grounding in accordance with the NEC.
- B. Connect the service ground and equipment ground to a common point within the metallic enclosure containing the main service disconnecting means. From the common point of connection of the service ground and equipment ground, run in conduit a combined service and equipment grounding conductor (grounding electrode conductor) without joint or splice to the grounding electrode system. At each end point of connection, attach the metal conduit containing the grounding electrode conductor to the grounding electrode, or bond the grounding electrode conductor to its conduit as it exits the conduit with a fitting selected for this purpose. Separate bonding jumpers are not permitted for bonding the conduit to the electrode.

### 3.2 GROUNDING ELECTRODE SYSTEM

- A. Ground rods
- B. Building steel
- C. Water service line
- D. Concrete-encased electrode (Ufer ground)

### 3.3 EQUIPMENT GROUNDING CONDUCTORS

- A. Comply with NEC Article 250 for types, sizes and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by NEC are indicated.
- B. Install a separate, green-insulated, equipment grounding conductor in each feeder and each branch conduit. Install the grounding conductor in the same raceway with related phase and neutral conductors, and connect to pull boxes or outlet boxes at intervals of 100 feet or less. Where paralleled conductors in separate raceways occur, provide a grounding conductor in each raceway. Connect the grounding conductors to bare grounding bars in panelboards, and ground busses in service equipment to the end that there will be an uninterrupted grounding circuit from the point of a ground fault to the point of connection of the equipment ground and system neutral.
- C. Install equipment grounding conductors in nonmetallic raceways unless they are designated for telephone or data cables.
- D. Install equipment grounding conductors in all flexible metal conduit and liquid-tight flexible metal conduit.

### 3.4 INSTALLATION

#### A. Ground Rods:

1. Install at least 3 rods spaced at least one rod length from each other and located at least the same distance from the other grounding electrodes.
2. Drive rods until tops are 2 inches below finished floor or final grade, unless otherwise indicated.
3. Interconnect ground rods with no. 2/0 bare, tinned, stranded copper 24" below grade. Attach with exothermic welds except at test wells.

#### B. Metallic Water Service Pipe:

1. Clean contact surfaces thoroughly to assure good metal to metal contact.
2. Where a dielectric fitting occurs on the water main, connect the grounding conductor on the street side of the fitting.
3. Connect to the pipe with a grounding fitting designed to attach the grounding conductor and its conduit to the pipe.

#### C. Grounding Building Steel: The building structural steel frame shall be grounded to the grounding electrode system.

### 3.5 FIELD INSPECTION AND TESTING

#### A. Inspection:

1. Visually verify proper grounding connections at the service entrance equipment.
2. Visually verify proper connections to the grounding electrode system.
3. Visually verify proper grounding connections of separately derived systems.
4. Visually verify proper grounding connections at emergency generators.
5. Visually verify proper grounding connections at distribution panels and branch circuit panels.

#### B. Testing:

1. Perform ground impedance measurements using the fall-of-potential method described in IEEE Standard 81. Instrumentation utilized shall be specifically designed for ground testing.
2. The testing shall be performed before the electrical distribution system is energized, and shall be made in normally dry conditions not less than 48 hours after rainfall, and without moistening the ground.
3. The impedance-to-ground of the main grounding electrode system shall be 5 ohms or less.
4. Where tests show an impedance to ground of more than 5 ohms, take action to decrease this value to 5 ohms by driving and interconnecting additional ground rods, installing ground plates, or installing chemical electrodes.

END OF SECTION 16170

## SECTION 16195 – ELECTRICAL IDENTIFICATION

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SCOPE

- A. Provide and install electrical identification for electrical conductors and equipment.

#### 1.3 QUALITY ASSURANCE

- A. Comply with National Electrical Code (NEC).
- B. Comply with UL Standard 969.
- C. Comply with ANSI C2.
- D. Comply with NEMA WC-1 and WC-2.

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable.
  - 1. W. H. Brady
  - 2. Ideal Industries, Inc.
  - 3. Seton Nameplate Co.
  - 4. Panduit Corp.

#### 2.2 EQUIPMENT NAMEPLATES AND SIGNS

- A. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.
- B. Engraved Plastic Nameplates:
  - 1. Melamine plastic laminate, minimum 1/16” thick for signs up to 20 sq. inches, and 1/8” thick for larger sizes.
  - 2. White letters on black face for equipment connected to normal power system.
  - 3. White letters on red face for equipment connected to emergency power system.
  - 4. Attach with self-tapping stainless-steel screws, except contact-type permanent adhesive can be used where screws can not or should not penetrate the surface.

## 2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coded Plastic Tape: Provide manufacturer's standard self-adhesive vinyl tape not less than 3 mils thick by 1-1/2" wide.
- B. Identification Bands: Provide manufacturer's standard vinyl or vinyl-cloth, self-adhesive, wraparound type with preprinted numbers and letters to show circuit identification.

## 2.4 UNDERGROUND LINE WARNING TAPE

- A. Permanent, bright colored, continuous printed, vinyl tape.
  - 1. Not less than 6 inches wide by 4 mils thick.
  - 2. Compounded for permanent direct burial service.
  - 3. Embedded continuous metallic strip or core.
  - 4. Printed legend indication type of underground line.

# PART 3 – EXECUTION

## 3.1 INSTALLATION

- A. Install electrical identification products in accordance with the manufacturer's written instructions, and requirements of NEC and OSHA.
- B. For items attached with adhesive, degrease and clean the surface as recommended by the manufacturer.
- C. Where items attach to surfaces that require painting, attach after completion of painting.
- D. Install signs at locations for most convenient viewing without interference with operation and maintenance of equipment.
- E. Identification on Boxes:
  - 1. Boxes for fire alarm circuits shall be painted red.
  - 2. Every box containing circuit wiring shall have the circuit numbers marked on the outside cover of the junction box. Use indelible marker with wide tip. Markings for normal circuits shall be black, and shall be red for emergency circuits.

## 3.2 CONDUCTOR IDENTIFICATION

- A. Apply conductor identification on each conductor in each box, enclosure, cabinet and panel.
- B. Refer to Section 16120 for color-coding of conductors.

## 3.3 MARKING EXTERIOR UNDERGROUND LINES

- A. During trench backfilling for power, control, signal, and communication lines, install continuous underground plastic line marker located directly above the line at 12 to 16 inches below finished grade.



### 3.4 EQUIPMENT IDENTIFICATION

- A. Install engraved, plastic laminate sign on each unit of electrical equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems unless the units contain their own self-explanatory identification.
- B. Unless otherwise indicated, provide a single line of text with ½” high lettering on 1-1/2” high sign (2” high where 2 lines are required).
- C. Text shall match the notations used on the drawings for identification.

### 3.5 IDENTIFICATION OF PANELBOARDS, SWITCHBOARDS, AND SWITCHGEAR

- A. Install engraved plastic laminate sign containing 3 lines of text. The top line shall be the panel name. The centerline shall indicate the panel voltage, and the bottom line shall indicate the source of supply.
- B. Signs for equipment fed from the normal system shall have white letters on black background, and equipment fed from the emergency system shall have white letters on red background.
- C. An example of the required identifications is:

Panel 4HA  
277/480  
Fed From Panel 4DP

END OF SECTION 16195

## SECTION 16441 – SAFETY SWITCHES

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit the following information for review:
  - 1. Complete drawings showing dimensions.
  - 2. Conduit entry/exit locations.
  - 3. Voltage rating, continuous current rating, and short-circuit rating.
  - 4. Cable terminal size.
  - 5. Fuse rating and type.

#### 1.3 SCOPE

- A. Provide, install, and connect all safety switches shown on the drawings or required by codes.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards. Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. Underwriters Laboratories, Inc. (UL)  
UL 50 Enclosures for electrical Equipment  
UL 98 Enclosed and Dead-Front Switches
  - 3. National Electrical Manufacturers Association (NEMA)  
No. 250 Enclosures for Electrical Equipment

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable:
  - 1. Square D
  - 2. Cutler Hammer
  - 3. General Electric

## 2.2 HEAVY DUTY SWITCHES

- A. Requirements: Provide and install safety switches as shown on the drawings or as required by NEC. Where code requires the installation of safety switches that are not shown on the drawings, provide and install the required switches.
- B. All switches shall be heavy-duty type.
- C. Switches shall be fusible or non-fusible as noted on the drawings or as required by codes.
- D. Provide switches with the voltage and current ratings as shown on the drawings.
- E. Where safety switches serve as motor or motor starter disconnects, provide horsepower rated switches with auxiliary contacts to disconnect all power and control circuits.
- F. Construction:
  - 1. Switch blades and jaws shall be plated copper.
  - 2. Switches shall have a handle that is easily padlockable in the OFF position.
  - 3. Switches shall have defeatable door interlocks that prevent the door from opening when the handle is in the ON position.
  - 4. Switch assembly and operating handle shall be an integral part of the enclosure base.
  - 5. Switches rated 100A to 600A shall have reinforced fuse clips.
  - 6. Switch blades shall be readily visible in the OFF position.
  - 7. Switch operating mechanism shall be non-teasible, positive quick-make / quick-break type.
  - 8. Fusible switches shall be suitable for service entrance equipment.
  - 9. Switches shall have line terminal shields.
  - 10. Switches shall have CU/AL mechanical lugs.
- G. Enclosures:
  - 1. Where installed indoors, all enclosures shall be NEMA I, general purpose type unless otherwise noted.
  - 2. Where installed outdoors, all enclosures shall be NEMA 3R, raintight type unless otherwise noted.
  - 3. Where noted on the drawings, provide the following enclosures:
    - a. NEMA 4 – watertight (304 stainless steel).
    - b. NEMA 12 – dust tight/oil tight.

## PART 3 – EXECUTION

### 3.1 INSTALLATION

- A. Install safety switches in accordance with manufacturers written instructions and NEC requirements.
- B. Install adjacent disconnects at the same height.
- C. Install disconnects to maintain the required NEC clearances and working space.

### 3.2 IDENTIFICATION

- A. Identify and color-code conductors in safety switches as specified under WIRES AND CABLES Section.
- B. Install engraved plastic sign on each safety switch as specified in ELECTRICAL IDENTIFICATION Section.
- C. The sign shall contain 3 lines of text. The top line shall identify the load served. The center line shall indicate the voltage. The third line shall indicate the source of supply.
- D. An example of the required identification is:

AHU #2  
480 V  
Fed From Panel PP

### 3.3 FIELD QUALITY CONTROL

- A. Inspection:
  - 1. Visually inspect each switch for proper grounding connections as specified under GROUNDING AND BONDING Section.
  - 2. Visually verify proper color-coding of conductors in safety switches as specified under WIRES AND CABLES Section.
  - 3. Verify fusible switches contain proper type and size of fuses.
- B. Testing:
  - 1. Test cable mechanical connections to the manufacturers recommended values with calibrated torque wrench.
  - 2. Operate each switch ON and OFF four times to verify proper operation.
  - 3. Energize circuit and verify proper operation.

END OF SECTION 16441

## SECTION 16470 – PANELBOARDS

### PART 1 – GENERAL

#### 1.1 NOTE

- A. The general provisions of the Contract including Uniform General Conditions and Supplementary General Conditions, Special Conditions and General Requirements (Division 1), apply to the work specified in this section.

#### 1.2 SUBMITTALS

- A. Submit the following information for review:
  - 1. Complete drawings showing dimensions.
  - 2. Conduit entry/exit locations.
  - 3. Voltage rating, continuous current rating, and short-circuit rating.
  - 4. Cable terminal sizes.
  - 5. Catalog product sheets.
  - 6. Nameplate Identification.

#### 1.3 SCOPE

- A. Provide, install, and connect all electrical panelboards shown on the drawings and specified herein. Panels shall be complete assemblies including enclosures, bussing, overcurrent protective devices, and trim.

#### 1.4 QUALITY ASSURANCE

- A. Referenced Standards. Provide products that comply with the referenced standards. These Standards are incorporated into this Specification by reference.
  - 1. National Fire Protection Association (NFPA)  
No. 70 National Electrical Code (NEC)
  - 2. Underwriters Laboratories, Inc. (UL)
    - UL 50 Cabinets and Boxes
    - UL 67 Panelboards
    - UL 489 Molded Case Breakers / Enclosures
  - 3. National Electrical Manufacturers Association (NEMA)
    - PB-1 Panelboards
    - No. 250 Enclosures for Electrical Equipment
    - AB-1 Molded Case Circuit Breakers

### PART 2 – PRODUCTS

#### 2.1 ACCEPTABLE MANUFACTURERS

- A. Subject to project requirements, products manufactured by (but not limited to) the following companies are acceptable:

1. Square D
2. Cutler Hammer
3. General Electric

## 2.2 PANELBOARD REQUIREMENTS

- A. All panelboards shall be listed by Underwriters Laboratories.
- B. The building main panel shall be listed as suitable for "Service Entrance Equipment".
- C. Panels shall be arranged for flush mounting, surface mounting, or free-standing as indicated on the drawings.
- D. Panels shall have the voltage ratings, continuous current ratings, and interrupting ratings as scheduled on the drawings.
- E. All panelboard accessories and features scheduled or specified on the drawings shall be provided.
- F. Where a circuit protective device is scheduled as a "spare", provide the device complete for operation. Where the device is scheduled as a "space" or "space only", provide proper space and all necessary connectors for future installation of the size of device scheduled. Where the device is scheduled to serve a "future" load, provide the device complete for operation.
- G. All circuit breakers shall be quick make, quick break, trip-free, thermal magnetic indicating type unless otherwise noted.
- H. Branch circuit breakers shall be fully interchangeable without disturbing adjacent units.
- I. Connect all overcurrent protective devices with sequence phasing.
- J. Provide each panelboard with a neatly typewritten directory of circuits mounted in a plastic covered cardholder on the inside of the panelboard door.
- K. Install laminated plastic nameplate for each panel as specified under ELECTRICAL IDENTIFICATION Section.

## 2.3 CONSTRUCTION

- A. Cabinets:
  1. Rigidly constructed of galvanized sheet steel per UL 50 Standards. Corners shall be overlapped or welded with the edges turned over to receive trim.
  2. Where two-section panels are required, both sections shall be same height, and have fully rated bussing in separate cabinets connected by conduit nipples.
- B. Trim:
  1. Fabricated from sheet steel meeting the requirements of UL 50 Standards. Trim shall have medium gray enamel finish suitable to serve as the final finish, or suitable to receive field painting.
  2. Trim door shall have rounded corners and edges free from burrs.

3. Surface trims shall be the same height and width as box. Flush trims shall overlap the box  $\frac{3}{4}$ " on all sides.
4. Furnish each door with substantial flush, cylinder tumbler lock and catch. Doors more than 48" high shall have auxiliary fasteners. Provide each lock with 2 keys. All locks shall be keyed alike.
5. Unless noted otherwise, interior mounted panels shall have type 1 fronts (one piece with hinged door). Where door-in-door construction is specified, it shall consist of a hinged door within a piano-hinged cover secured with trim clamps.
6. Exterior mounted panels shall be type 3R in accordance with UL 50 requirements. All doors shall be gasketed and be equipped with a tumbler type vault lock and two additional trunk type latches.

C. Bussing:

1. All bussing shall be plated copper sized in accordance with UL Standards to limit temperature rise on any current-carrying part to a maximum of 65 degrees C above an ambient of 40 degrees C maximum.
2. Main lugs and main breakers shall be UL approved for copper conductors sized to accommodate the conductors to be terminated. Provide oversized lugs to terminate conductors that are increased in size due to voltage drop or temperature requirements.
3. A bolted ground bus shall be included in all panels. Where scheduled, an isolated ground bus shall also be included.
4. A full size (100%) neutral bar shall be furnished for panels shown with neutral. Neutrals shall have suitable lugs for each outgoing feeder requiring neutral connection. Where scheduled, provide 200% rated neutrals with lugs for oversized neutral conductors.

## 2.4 DISTRIBUTION PANELS – CIRCUIT BREAKER TYPE

- A. Distribution panels with bolt-on devices contained therein shall have fully rated interrupting ratings to interrupt fault current values indicated on the drawings. Breakers shall be molded case type.
- B. Molded case circuit breakers shall provide overcurrent and short circuit protection with inverse time and instantaneous tripping characteristics. Also provide ground fault protection where scheduled.
- C. Circuit breakers shall operate by toggle-type handle and shall be quick make, quick-break switching mechanism that is mechanically trip-free. Automatic tripping of the breaker shall be clearly indicated by the handle position.

## 2.5 DISTRIBUTION PANELS – FUSIBLE SWITCH TYPE

- A. Distribution panels shall have fusible switches for fuses in the ratings shown on the drawings.
- B. Fusible switches shall be quick-make, quick-break design. Units 30 thru 600 amperes shall be rated not less than 200 kAIC with rejection-type fuse clips for Class R fuses. Units 800 and 1200 amperes shall be rated for 200 kAIC with Class L fuse provisions.
- C. Fuses shall be field installed.

## 2.6 LIGHTING AND APPLIANCE PANELS

- A. Bolt-in type, heavy duty, quick-make, quick-break, single- and multi-pole molded case circuit breakers with toggle handles that indicate when unit has tripped.
- B. Circuit breakers shall be thermal magnetic type with common handle for all multiple pole breakers.
- C. Breakers shall be UL listed as type SWD for lighting circuits.
- D. Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights and fire alarm panels.
- E. Breakers shall be fully rated to interrupt the fault current values scheduled on the drawings.
- F. Provide breaker accessories as scheduled on the drawings.
- G. Where a lighting and appliance panelboard contains more than 42 branch overcurrent devices, the assembly shall consist of two or more separate boxes with each box containing not more than 42 branch overcurrent devices.

## PART 3 – EXECUTION

### 3.1 INSTALLATION

- A. Install panelboards in accordance with manufacturers written instructions, NEMA PB1.1 and NEC standards.
- B. Panelboard enclosures shall be securely fastened to the structure with a minimum of four bolts or screws.
- C. Clean dirt and foreign paint from exterior and interior of all panels.
- D. Do not splice conductors in panels.
- E. Conductors not terminating in panelboard shall not extend through or enter panel enclosure.
- F. A single conductor shall terminate in each lug on a circuit breaker. Do not terminate multiple conductors under a single lug.
- G. During installation carefully balance the electrical loads between the various phases. This may require connecting loads to circuits different from the circuit numbers indicated on the drawings.

### 3.2 IDENTIFICATION

- A. Identify and color-code conductors in panelboards as specified under WIRES AND CABLES Section.
- B. Install panelboard nameplate identification as specified under ELECTRICAL IDENTIFICATION Section.



- C. Provide individual circuit identification for each circuit with a type-written directory of circuits mounted in a holder on the inside of the panel door. The directory shall identify the type or name of the load served along with the room names and numbers. The room names and numbers shall be the final names and numbers assigned to the space and not those used on the drawings.

### 3.3 FIELD QUALITY CONTROL

#### A. Inspection:

1. Visually inspect each panel for proper grounding connections as specified under GROUNDING AND BONDING Section.
2. Visually inspect breakers and switches for broken parts and loose terminals.
3. Visually verify proper color-coding of conductors as specified under WIRES AND CABLES Section.
4. Visually verify panelboard trim fits properly with no gaps between the trim and panel enclosure.

#### B. Testing:

1. Test cable mechanical connections to the manufacturers recommended values with calibrated torque wrench.
2. Operate each breaker ON and OFF to verify proper operation.
3. Energize circuits and demonstrate proper operation.
4. When the facility is under normal use, amperage measurements shall be taken on each phase conductor in each panel feeder, and any unbalances shall be corrected to a point that no conductor load shall be more than 5% high or low (maximum unbalance of 10%).

END OF SECTION 16470