SECTION 22 21 13.23

SCHEDULE 40 STEEL PIPE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This unit consists of furnishing and installing a piping system to conduct a medium from one place to another.

PART 2 - PRODUCTS

2.1 PIPE

A. Schedule 40-Steel Pipe to comply with the latest revision of ASTM Specification A-120. Grades A and B.

B. Piping under this specification should be used for low pressure steam water and gas piping. It should not be used for close bends or coils, or for high temperatures.

C. Schedule 40 - Steel Pipe to comply with the latest revision of ASTM-Specification A-53. Grades A and B.

D. Piping under this specification is recommended for the higher temperature range and where bends are required. For Coil Construction, Grade A is recommended.

2.2 JOINTS

A. For threaded joints, pipe threads shall conform with the latest revision of ANSI Specification B 2.1.

B. For hose couplings, threads shall conform with the latest revision of ANSI Specification B 33.1

C. For fire hose couplings, threads shall conform with latest revision of ANSI Specification.

2.3 FITTINGS

A. Cast iron screwed fitting shall conform with the latest revision of ANSI Specification B 16d. Material for cast iron screwed fittings must conform with latest revision of ASTM Specification A 126 Class A.

B. Malleable iron screwed fittings shall conform with the latest revision of ANSI Specification B 16C. Material for malleable iron screwed fittings shall conform with the latest revision of ASTM Specification A 157.
C. Ferrous plugs, bushings, locknuts and caps with pipe threads shall conform with the latest revision of ANSI Specification B 16.14.

### 2.4 FLANGED JOINTS

A. Class 25-pound cast iron pipe flanges and flanged fittings shall conform with the latest revision of ANSI Specification B 16.b2.

B. Class 125 pound cast iron pipe flanges and flanged fittings shall conform with the latest revision on ANSI specifications B 16 and B 16.a1.

C. Class 250 pound cast iron pipe flanges and flanged fittings shall conform with the latest revision of ANSI specification B 16.b1.

D. 800 pound hydraulic cast iron flanges and flanged fittings shall conform with the latest revision of ANSI specification B 16.b1.

E. Gray iron castings for flanged fittings shall conform with the latest revision of ASTM specification A 213 and A 126.

F. Cast alloy steel flanges shall conform with the latest revision of ASTM specification A 351 and A 217.

G. Forged carbon steel flanges shall conform with the latest revision of ASTM specification A 105, A 181 and A 182.

H. Bolted flanged connections shall conform with the rules of ASME United Pressure Vessel Code paragraph UA 18 and UA 24.

I. Forged or rolled steel pipe flanges, forged fittings for high temp service shall conform with the latest revision of ASTM specification A 105.

J. Steel pipe flanges and fittings shall conform with the latest revision of ANSI specification B 16C.

K. Synthetic rubber and corrugated or plain copper gaskets shall conform with the latest revision of ASME rules for bolted flange connections table UA 7.

L. Bolts-Wrench head bolts and nuts and wrench opening bolts for flanged connections table conform with the latest revision of ANSI specification B 18.2.

M. Screw threads for high strength bolting for flanges connection, shall be threaded to conform with the latest revision of ASTM specification A 193.

N. Nuts for wrench head nuts and wrench opening shall conform with the latest revision of ANSI specification B 18.2.
O. Welded joints shall conform with the latest revision of ANSI Pressure Piping Code Specification B 31.1, Section 6.

P. Qualified welders for welded joints shall conform with the qualifications Test of the latest revision of ANSI specification A 31.1.

Q. Butt welds shall conform with the latest revision of ANSI specification B 16.9.

R. Sockets welds shall conform with the latest revision of ANSI specification B 16.11.

S. Welding rods for gas welding shall conform with the latest revision of AWS.

T. Welding electrodes for electric arc welding shall conform with the latest revision of AWS.

U. Backing rings shall conform with the standards of the latest revision of ANSI code for pressure piping specification B 31.1.

V. Valves - cast iron double disk flanged gate valves shall conform with the latest revision of ANSI specification B 16.10.

W. Cast iron and steel flanged wedge gate valves shall conform with the latest revision of ANSI specification B 16.10.

X. Cast iron and steel flanged globe and angle valves shall conform with the latest revision of ANSI specification B 16.10.

Y. Forged steel flanged gate and globe valves shall conform with the latest revision of ASTM specification A-105.

Z. Gray iron castings for flanged valves shall conform with the latest revision of ASTM specification A 126.

AA. Screwed and flanged gate and bronze valve bodies shall conform with the latest revision of ASTM specifications B 61 and B 62.

BB. Screwed and flanged check valve bodies shall conform with the latest revision of ASTM specification A 126.

CC. Screwed or flanged iron check valve bodies shall conform with the latest revision of ASTM specification A 126.

2.5 **TRANSPORTATION, UNLOADING AND STORAGE**

A. Piping shall be unloaded and stored in a dry place taking specific care to protect all threads. All threaded pipe ends should be protected with a cap or union.
PART 3 – EXECUTION

3.1 WORKMANSHP

A. It is desired to obtain a piping system with good appearance and solidly constructed.

B. All piping should be installed as shown in the drawings.

C. All pipe sizes 2 inches or less shall have threaded connections unless otherwise indicated in the drawings.

D. All pipe sizes 2½ inches or larger shall be welded unless otherwise indicated in the drawings.

E. All valves 2 inches or smaller shall have threaded connections unless otherwise indicated in the drawings. All valves shall be provided with unions so they can be disconnected without disturbing the piping layout.

F. All valves 2½ inches or larger shall have flanged connections unless otherwise indicated in the drawings.

G. Galvanized steel pipe shall be threaded or flanged connected. Under no circumstances welding shall be allowed in galvanized pipe.

H. All horizontal lines shall be installed to permit complete drainage of the system through the lowest point.

I. All steam lines shall have drip leg in all low points and on all line ends larger than 25 feet. Drip legs shall be of the same diameter as the line up to 4 inches and 4 inches minimum for larger lines of the sizes shown in the drawings. Drip legs shall be 6 inches long unless the circumference of the drainage line is larger than this valve. In these cases the length of the drip legs should be the same as this valve.

J. All condensate return shall be trapped as shown in the drawings and all traps shall have drip legs 6 inches long with plug valves and shall be pitched towards the condensate tank.

K. Whenever it is indicated eccentric reducer shall be used to allow complete drainage of the system.

L. Whenever eccentric reducers are used to connect liquid headers of different sizes, the upper parts of reducers and pipes should be at the same level.

M. When threaded connections are used, all threads should be reamed and the pipe thoroughly cleaned before the joint to each fitting or valves is tightened. Male threads should be lubricated with while lead, graphitized oil or approved compound being careful not
to spill the compound in the last two threads or in the inside of the pipe.

N. On welded connections larger than 2 inches, backing ring shall be used. Pipe and fittings shall be cut and beveled before welding by machining sawing, grinding or chipping. Flame cutting may be used unless excluded in the specifications but the edges to be welded must be uniform, smooth and free of loose scale and slag before welding.

O. No preheating shall be required unless specifically called for in the specifications.

P. No stress relieving will be necessary unless specifically called for in the specifications.

Q. In low pressure welds all sing or flux shall be removed from each crater by means of a light cleaning hammer before proceeding with the next electrode.

R. Each completed head or layer shall be thoroughly cleaned with a wire-briddled hand brush. Surface defects shall be chipped out, by the welder, using a hammer and hard chisels.

S. When close bends are fabricated the curvature radius shall be a minimum of four times the diameter of the pipe.

T. For pipe sizes 3 inches and small, cold bends shall be allowed using rod benders.

U. For pipe sizes from 6 to 8 inches no bending shall be allowed using a press or a hydraulic bending machine.

V. For pipe size from 6 to 8 inches no bending shall be allowed by using large forges or gas burners and filling the pipe with sand. Pipe should be mounted on a bending slab preparatory to heating and the free end should be pulled around a few degrees after each heating.

W. Pipe sleeves shall be provided for all pipes passing through walls, or slabs.

X. Wall sleeves shall extend 3 inches above the finished floor level.

Y. When thermal insulation is specified, pipe sleeves shall allow the insulation to pass without interference and without touching the walls of the pipe sleeve. In all connections from mains to branches adequate valves shall be provided and in all main rungs and branches when called for in the specifications for the sectionalization of the circuits.

Z. All pressure reducing stations and connections to equipment shall be provided with gate valves to permit removal of the equipment.
AA. Valves up to 2 inches shall be threaded and 2½ inches or larger flanged.

BB. When open or shut operation is indicated in the specifications, gate valves shall be used except in gas service where lubricated cock valves shall be used.

CC. For throttling services, globe valves shall be used except when the specifications call for an specific throttling type valve.

DD. Where flow in one direction is called for in the specification check valves shall be used.

EE. All high points on the piping system shall have purge connections with either manual or automatic devices as called for in the specifications.

FF. When called for in the specifications expansion joints or loops shall be provided to prevent transmission of stresses to the pipe supports or the building structure.

3.2 NECESSARY EQUIPMENT

A. The Contractor shall provide all the necessary equipment as called for in the specifications to obtain a first class job in accordance with all applicable codes.

3.3 TESTS

A. All pipes according to the specifications. Where pipes are thermally insulated test shall be done previously to the installation of the insulation.

B. For water brine and non-toxic mediums, pipe shall be tested at the design pressure.

C. Stream lines shall be tested at one and a half the design pressure.

D. Toxic medium shall be tested to conform with the standard procedure of the latest revision of ANSI specification B 31.1, paragraphs 121 and 634.

3.4 OTHER TRADES

A. Before commencing work the Contractor shall check to see that all necessary structural openings, cast in place pipe sleeves, cast in place anchorages for hangers and pipe supports have been installed or prepared.

B. In case that work covered by the Contractor of this unit requires completion of work done by other contractors, he shall make a careful inspection of the work to be done by other and should be
corrected before commencing his work. If the Contractor for this work unit commences to work, it shall be considered that he accepts as correct work done on the other units that may affect his work, so that any repairs that may be required shall be solely for his account.

3.5 PRECAUTIONS

A. Care should be taken that all lines run straight and parallel as shown in the drawings. The appearance of the system shall be pleasant and all piping, valves fittings shall be new and free of defects. Any defective materials shall be replaced. Any part of the system which fails the tests shall be replaced except in the case of threaded or flanged joints where tightening of the joint will be allowed to the limits in the specifications for bolted flanges of the latest revision of ASTM specifications.

3.6 GUARANTEE

A. All the work herein specified shall be free from labor and material defects for the time interval specified in the contract. The Contractor shall furnish a written statement covering the terms of this guarantee to the owner.

END OF SECTION
SECTION 23 00 00

AIR CONDITIONING VENTILATION AND/OR REFRIGERATION

1. GENERAL

a. Applicable provisions of the general conditions governing all contracts shall govern all work under this Section.

2. INTENT

a. It is the intent of the plans and specifications to provide complete air conditioning, ventilation, exhaust and refrigeration systems as outlined on the plans and specifications.

3. SITE INVESTIGATION

a. It shall be the responsibility of the Bidders to visit the site of the work and acquaint themselves with all available information regarding the location of existing facilities. Failure of the Bidders to fully inform themselves of all conditions and to include in their proposal a sum to cover the same sufficiently will not entitle them to an extra.

4. SCOPE

a. The work to be done under this heading includes the furnishing of all labor, materials, tools, plant and equipment, and in performing all operations in connection with the installation and placing in operation of complete automatic air conditioning, ventilation, exhaust and or refrigeration system as shown on the plans and herein specified.

5. PLANS AND SPECIFICATIONS

a. General: The plans and specifications are complementary to each other, so that material and workmanship indicated, called for or implied by the one and not by the other, shall be supplied and installed as though specifically called for by both. The drawings are to be considered diagrammatic, not necessarily showing in detail or to scale all of the minor items. It shall be the responsibility of the bidders to review and make themselves completely familiar with all architectural structural, electrical and mechanical drawings and to adjust his work to conform to all conditions indicated on them. Failure of the Bidders to fully inform themselves of all conditions and to include in their proposals a sum to cover the same sufficiently, shall not entitle them to an extra.
All items not specifically mentioned in the specifications or in the drawings but which are necessary to make a complete working installation shall be included in the Bidders proposal. Failure of the Bidders to do so will not entitle them to an extra.

b. Discrepancies: In the event of error in or omissions from the plans and specifications and of discrepancies between the drawings and specifications, or between either of these and any state, municipal, or other ordinances, the bidder shall notify the Architect-Engineer in ample time to permit revisions before the bids are submitted. Failure of the Bidder to do so will not entitle him to an extra.

6. EXECUTION OF WORK

a. General: All work performed under this contract, shall be accomplished by experienced personnel of the ASHRAE and those of the manufacturers of the equipment and materials involved. There shall be strict adherence to the Code requirements of the National Board of Fire Underwriter's, the city and other governing bodies having jurisdiction. All work shall be done in a neat and workmanlike manner and the premises shall be left clean and free of debris.

b. Equipment and Materials: All equipment and materials used in this installation shall be new, of the best quality, and shall be standard catalog items of the various manufacturers.

c. Shop Drawings and Data to be Submitted: The Contractor shall submit to the Architect-Engineer for approval all shop drawings and manufacturer's data on equipment and materials to be furnished under the contract and the work shall not proceed without approval.

d. Data to be submitted for approval in triplicate:

1) Self contained or Packaged air conditioners and or split systems.

2) Compressors, condensing units and condenser.

3) Liquid chillers.

4) Factory assembled air handling units.

5) Cooling coils selection figures.

6) Condensed and chilled water pumps.

7) Water pump head calculations.

8) Cooling Tower.
9) Remote air cooled condensers.
10) Refrigerant receivers and pressure tanks.
11) Air distribution products
12) Starters and electric motors.
13) Controls and control diagram.
14) Support and foundations.
15) Electrical wiring diagram.
16) Drawings of all changes in ductwork and or piping.

e. Guarantee: The Contractor shall be responsible for guarantees as hereinafter specified, and default during the guarantee period by equipment, manufacturers of his subcontractors shall not relieve him from liability.

7. LEGAL REQUIREMENTS

a. Rules and Regulations: All existing state and municipal laws are hereby made a part of these specifications and must be strictly adhered to and complied with in every respect without further notice.

b. Fees, Taxes, Permits, etc.: The Contractor shall obtain and pay all insurance, fees, permits, association dues, royalties, imposts and taxes of whatever nature that apply to this work unless otherwise noted.

He shall also pay all inspection fees as may be required by law or ordinances and shall keep the owner harmless from any damage and expense arising from any violation of the laws, rules or ordinances.

8. EQUIPMENT

a. General: Furnish and install where indicated on the drawings all equipment hereinafter specified or shown on the drawings or specifications.

b. Capacities: Capacities of equipment shall be as specified on the drawings or specifications.

c. Installation: Equipment shall be installed in accordance with the recommendations of the various manufacturers.
9. MATERIALS

Furnish materials in accordance with specifications and drawings.

a. Installation:

1) General: The installation of systems described in these specifications and plans will be performed by experienced personnel in this type of work, under the supervision of competent foremen, and in accordance with the recommended practices of the ASHRAE and those of the manufacturer of the equipment and materials involved, to obtain not only a functional installation but a neat installation.

2) Layout: Before installing ductwork and/or piping check plumbing, electrical, architectural and structural drawings against the drawings of the contract, and make accurate layouts of ductwork and or piping.

3) Interferences: Where interferences may appear, and departures from indicated arrangement are required, his Contractor shall consult with the other trades involved and come to an agreement as to changed locations and elevations for the ductwork and or piping, and shall obtain approval from the ArchitectEngineer for the proposed changes.

4) Foundations and Supports: Foundations and supports for all equipment in this contract shall be furnished by this Contractor, unless otherwise noted on the plans, as required or as recommended by the manufacturer of each piece of apparatus,

5) Cutting and Patching: The Contractor shall locate, layout and install all holes and sleeves in walls, ceilings, floors, etc., necessary for the installation of his work. The Contractor shall cooperate with the Contractors of the other divisions giving due and proper notifications regarding all such work.

10. TEST AND GUARANTEE

a. Testing: Test shall be performed as hereinafter specified during the course of the construction and at the conclusion of the work. The systems shall be tested in sections, as may be required by progress of the construction.

Chilled water and condenser water piping. Piping shall be hydraulically tested at 100 psig and proven tight for a period of 18 hours prior to covering.
1) Flushing and Draining: The Contractor shall flush the chilled and condenser water system with water or whatever chemical solution is required in order to remove all solder flux, dirt or foreign matter from the piping system. All strainers must be in place before each and every piece of equipment, evaporator condenser, coils, control valves, etc., while this flushing is being effected. The strainers must be cleaned periodically during the flushing operation and the flushing must be carried on until all strainers show perfectly clean after a continuous flushing, operation of at least 8 hours with the system completely full with clean water and using the specified chilled or condensing water pump at maximum specified flow.

2) Refrigerant Lines:

   a) Once the installation of the refrigerant lines and equipment is completed, the Contractor shall proceed to test them using dry nitrogen or carbon dioxide to build up 140 psig pressure at the low side and 250 psig at the high side if the refrigerant used is R11, R12, or R500 and 300 psig if it is R22 or R717.

   b) After the pressure test is finished the complete refrigerant system must be evacuated to 28" vacuum using a special pump and heating the lower points of the system with a torch. Under no circumstances the compressor shall be used to evacuate the system.

   c) The system shall be held at vacuum not less than 24 hours with the vacuum pump shut-off to satisfactorily check that no breaks or moisture exist. The owner and/or the Architect Engineer will be present during the test and the contractor shall notify them two days before the test is made.

   d) After the vacuum test is satisfactorily made the Contractor shall proceed to break the vacuum with such charge of the operating refrigerant as to build up a pressure of about 30 psig.

   e) The contractor will use a halide torch to detect any leak that may develop. If no leaks are found the Contractor shall charge the system with its complete operating charge. to put it into operation.

   f) If leaks are found, this 30 psig pressure will be evacuated and the test cycle repeated again, as many times as required to be sure that no leaks are found before the complete operating charge is introduced into the system.
g) Then, the Contractor shall place in operation the refrigeration system making all necessary adjustments to obtain a perfect operation.

3) Supply, Exhaust Fans and Air Handling Units: After all fan motors are properly energized for startup they shall be started to check if they are correctly rotating and running without any objectionable vibration or noise.

4) Final Tests:
   a) All systems shall be fully balanced both on the air and water side before final acceptance to achieve optimum performance.

   b) Characteristics. All air quantities must be approximated to the values shown in the drawings and then further adjusted below or above this valve in order to obtain a uniform temperature distribution in the area and a draftless air distribution with a maximum terminal velocity of 100 FPM unless lower velocities are required for special installations as in the case of supermarkets with open to refrigerated cases where a maximum terminal velocity of 25 FPM must be maintained. At the conclusion of the work of this Contract, this Contractor shall test and demonstrate to the satisfaction of the Owner and the Architect-Engineer, that the equipment is mechanically sound, that the systems delivers rated output without objectionable noise, distress or vibration and that the automatic temperature controls are functioning properly. Equipment instruments and services required to perform testing shall be furnished by this Contractor.

   c) Record of all reading of pressure, amperage, velocities, temperature relative humidity, air velocity, air amount and so on shall be delivered by this Contractor, in duplicate, to the Owner, together with the operating instructions for the system.

b. Operating Instructions: At the conclusion of the work, this Contractor shall thoroughly instruct the owner or his representative in the efficient operation of the installation for a period of not more than three days.

END OF SECTION
SECTION 23 02 00

EQUIPMENT HANDLING AND SETTING

PART 1 - GENERAL

1.1 SCOPE

A. This specification covers the handling and setting of equipment as listed on accompanying contract drawings and/or documents.

1.2 WORK BY OTHERS

A. Openings in the building structure.
B. All piping, utilities, and electrical service and connections.
C. Equipment painting.
D. Equipment insulation.

1.3 GENERAL

A. The Contractor shall furnish all supervision, labor, material, tools, and equipment to receive, unload, uncrate, inspect, move, disassemble, store (if necessary), assemble, set in place, align, and secure all equipment including all auxiliary items and components.

B. The installation sequence and work schedule shall be established by the Owner. The Contractor shall coordinate work with shipping schedules. Any anticipated delays in completion schedule due to delayed shipments, damaged materials or other causes shall be reported to the Owner's Representative immediately.

1.4 RECEIVING, UNLOADING, CHECKING AND STORING

A. Equipment delivered to the job site shall be received and unloaded promptly. Adequate personnel and proper unloading equipment shall be on hand to receive all items. Any demurrage charges incurred shall be paid by the Contractor.

B. For equipment purchased by the Owner, the Owner's Representative will receive and check the equipment and separately package parts against the bill of lading and will then turn over the shipment to the Contractor, who shall be responsible for unloading and subsequent handling. For equipment purchased by the Contractor, the Contractor shall check all items and then have the same responsibility.

C. Items that are received prior to the time when work has progressed sufficiently to allow immediate installation shall be stored and
protected in a manner prescribed by the manufacturer. Storage locations shall be as directed by the Owner.

D. Adequate weather protection of all equipment and equipment parts is to be furnished and maintained at all times by the Contractor. Guards, barricades, lights, etc. necessary for protection of persons and property shall be furnished and maintained. All requests by the Owner to enclose or specially protect any item of equipment or work shall be complied with.

E. Stored equipment shall be protected from the elements and physical damage. Installed equipment shall be protected from damage until final acceptance by the Owner's Representative.

F. Instruction manuals and repair kits shall be turned over to the Owner's Representative on the job site.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Inserts and Anchors

1. This section applies where equipment is supported from ceiling slabs, concrete walls, columns, and other building masonry (except floors).

2. Where support rod sizes exceed 7/8" diameter or where the load exceeds the recommended load for the insert or anchor, use two inserts or anchors with a trapeze type connecting member below the concrete.

3. Where installation can be made before the concrete is poured use universal concrete inserts as manufactured by ITT Grinnell, Fee & Mason and Elcen.


5. Where continuous inserts are required they shall be Unistrut roll formed from not less than 12 gage galvanized steel with anchors spaced on not less than 6" centers, and with end caps, splice plates, and bolts and nuts as required by conditions.

B. Floor Anchors

1. Before Concrete is Poured:
   a. For equipment that requires alignment, install foundation bolts inside of pipe sleeves.
b. For other equipment, install cast-in-place anchors of heavy structural steel or cast iron.

2. In existing concrete use Phillips "Red Head" expansion anchors, Rawl self-drilling anchors, Rawl Lok/Bolts, Hilti Kwik-Bolts.

C. Grout

1. As specified on contract documents and/or drawings.

2. If not specified on contract drawings/documents, grout shall be Unisorb V-1 manufactured by Unisorb Machinery Installation System, Jackson, Michigan, or approved equal.

PART 3 – EXECUTION

3.1 GENERAL

A. It is the responsibility of the Contractor to acquaint himself with each item of equipment, to foresee all of the work and materials involved, and to seek out any special handling required for any pieces of equipment.

B. Workmanship shall be of the highest quality, and shall meet all the standards set by the manufacturers of the equipment. All work shall be performed in strict accordance with manufacturer's drawings, manuals, and instructions. Careless work or unsatisfactorily installed equipment will not be accepted. Owner's Representative shall determine and decide whether installation and work performance is acceptable.

C. Floors shall be protected from all damage while moving and installing equipment. Adequate planking shall be provided to properly distribute loads applied while moving and installing equipment.

D. Large pieces of equipment shall be moved into their proper rooms prior to removing skids. Smaller pieces of equipment may be uncrated at any convenient location prior to moving into installation area. Instruments and sensitive equipment shall remain packed in cases until ready for installation.

E. Manufacturer's installation specialists (where consulted) shall have full authority in all matters concerning method of installation, preparation of materials, workmanship standards, etc. Activities under these specifications shall be coordinated so as not to unduly retain manufacturer's specialists at the jobsite, and letters of acceptance shall be obtained prior to their leaving the project.

F. When handling multi-component equipment (e.g., pump-motor assemblies, fillers with attached hoppers), extreme care shall be
exercised to prevent misalignment, separation, etc. of the components.

G. Building steel shall not be cut, drilled or welded to support equipment without the approval of the Owner's Representative.

H. No mechanisms or apparatus required for handling equipment shall be attached to building structural steel without the approval of the Owner's Representative.

I. All equipment shall be set on centerlines and elevations as per plan and elevation drawings.

J. The Contractor shall furnish all shims, liners, wedges and plates that are required to properly align or level equipment. He shall also furnish all bolts, nuts, washers, gaskets and similar incidental materials that may be required to make the installation complete.

K. The Contractor shall check all anchor bolts before attempting to set equipment. Sleeves shall be cleaned out and bolts properly positioned. He shall complete necessary aligning, drilling, welding, tapping and re-aligning of equipment supports, drives, bearings or other components not so done by manufacturer or other trades. He shall assemble and install all equipment complete with motor, drives, couplings, guards and other appurtenances.

L. At the completion of each day's work the Contractor shall dispose of all crating materials and other debris he has created, and leave the areas broom-cleaned.

M. Grouting

1. Follow preparation and installation instructions of grout manufacturer.

2. Remove all dirt, oil, grease and other foreign material from concrete and steel surfaces. Break away all defective concrete, leaving a level roughened surface.

3. Install equipment to provide a minimum 1" clearance between the top of the concrete and the underside of the equipment base. After equipment is in place and properly leveled and aligned, tighten foundation bolts evenly but not too firmly.

4. Completely fill the 1" space with grout; grout the leveling pieces, shims or wedges in place. Be sure there are no air pockets or hollow areas beneath the equipment.

5. After the grout has completely hardened, finish tightening the foundation bolts.
3.2 INSPECTION AND ACCEPTANCE

A. All installation work will be inspected by the Owner and/or equipment manufacturer. The Contractor shall have personnel available for rotation check and final alignment during inspection and start up.

B. The Contractor shall obtain acceptance in writing from the Owner. Installation work will not be considered complete until such written acceptance is obtained.

END OF SECTION
SECTION 23 05 93

TEST AND BALANCE OF AIR SYSTEMS
AND CHILLED AND HOT WATER SYSTEMS

PART 1 – GENERAL

1.1 SCOPE OF WORK

A. Work shall consist of testing, balancing and adjusting of all air and water systems and components called for on the drawings and/or other contract documents. This shall be accomplished as follows:

1. Obtain the required air quantities at various operating conditions of the system to demonstrate compliance with the design. This will require simulation of maximum pressure drops due to dirty filters and wetted cooling coils, and, in the case of Variable Air Volume systems, variation of air volume through the range from minimum to maximum.

2. Obtain the chilled water quantities required by the various components, equipment and devices.

B. All work shall be performed by an independent test and balance agency under direct supervision of a qualified heating and ventilating engineer approved by Owner. All instruments used shall have been accurately calibrated within the last six months and maintained in good working order. (Affidavits attesting to the date, method(s) of calibration, and by whom calibrated shall be furnished to the Owner's Engineer prior to the initiation of the work and included in the final report). The tests shall be conducted in the presence of the Owner's Engineer and/or his representative. Test and Balance (TAB) Contractor and Owner's Representative shall meet at least 2 weeks prior to the anticipated start of testing to finalize procedures and assure complete understanding of the methods to be used.

C. Testing and balancing shall not begin until systems have been completed and are in full working order. The Mechanical or Heating Ventilating and Air Conditioning Contractor shall put all ventilating and air conditioning equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

D. TAB Contractor shall include an extended warranty of 90 days after completion of test and balance work and submission of the report, during which time the Owner's Representative at his direction may request a recheck or resetting of any outlet, supply air fan, exhaust fan, control valves or balance valves to adjust flows as listed in test report. The agency shall provide technicians to
assist the engineer in making any tests he may require during this period.

E. Upon the completion of the systems, the TAB Contractor shall perform the following tests, compile the test data, and submit two preliminary copies of the complete test data to the Owner for evaluation and approval. Submission shall be within two weeks after test completion. Seven copies of the approved data shall be submitted within two weeks following approval. In addition, one marked-up set of mechanical drawings indicating and identifying test point locations shall be furnished.

F. The TAB Contractor shall check all controls for proper calibration and furnish a list of all controls needing adjustment. Any controls needing adjustment shall be attended to by the Controls Contractor, and this Contractor shall validate and verify the adjustment repeating the process until satisfactory operation is achieved.

1.2 SYSTEMS DESCRIPTION

A. The Architect-Engineer shall furnish to the TAB Contractor flow diagrams indicating test parameters, design values and system test conditions required. The TAB Contractor shall be responsible for the testing results.

1.3 AIR BALANCE PROCEDURE

A. The following procedure need not be followed in the exact sequence listed herein; however, all requirements indicated shall be met.

B. Preparation of Systems

1. Set all supply and return air duct dampers at full open position. Use factory setting as starting point.

2. Set all diffuser and side wall grilles at full open position.

3. Set outside air damper at minimum position.

4. Set branch line splitter dampers to open position. Set all extractors and distribution grids in wide open positions.

5. In cooperation with Controls Contractor, set and adjust all control dampers and automatic air control devices to achieve design performance.

6. Determine that all air moving equipment is operating within design range.

7. Drill all probe holes (7/16" diameter) for static pressure readings, Pitot tube traverse readings and temperature readings. Mark test points on duct plan drawing and identify
on ductwork. After completion of balancing, holes shall be plugged with airtight hole plugs to leakage specified.

8. Check motor electrical current supply and rated running amperage of fan motors.

9. Check fan and motor speeds, including available adjustment range.

C. Balancing Procedure

1. Systems without automatic constant air volume devices:
   a. Make first complete air distribution run throughout entire system with simulated dirty filters and wet coil resistances (Condition #1); see sketch. Record first run statistics for submission.
   
   b. Using Pitot tube, traverse the supply and return main and branch ducts. Proportion all air in relation to specified to the main branch runs, using duct volume control devices.
   
   c. Make second complete air distribution run throughout entire system for check on proper proportion of air.
   
   d. Adjust fan speed to deliver total specified air flow.
   
   e. Using Pitot tube traverse, set all main line dampers to deliver proper cfm to all areas.
   
   f. Using Pitot tube traverse, set all branch line dampers to deliver proper cfm to diffusers and side wall supply grilles in each zone.
   
   g. Read cfm at each outlet and adjust to meet requirements.
   
   h. Test and record all items as listed in paragraph 1.3 D.
   
   i. Repeat above steps for clean filters (Condition #2).

D. Test and Record Items

1. Test and adjust each blower RPM to design requirements.

2. Test and record each motor full load amperage.

3. Make Pitot tube traverse of main supply ducts and obtain design cfm at fans.

4. Measure coil face velocities.
5. Test and record system static pressure; i.e. filter "clean and dirty", cooling and heating coils, fan suction and discharge, air flow measuring stations, etc.

6. Test and adjust system for design recirculated air, cfm.

7. Test and adjust system for design outside air, cfm.

8. Test and record entering air temperatures. (D.B. cooling).

9. Test and record entering air temperatures. (W.B. cooling).

10. Test and record leaving air temperatures. (D.B. cooling).

11. Test and record leaving air temperatures. (W.B. cooling).

12. Adjust all main supply and return air ducts to proper design cfm.

13. Adjust all zones to proper design cfm, supply and return.

14. Test and adjust each diffuser, grille, and register to within 10 percent of design requirements for system.

15. Identify each grille, diffuser, and register as to location and area.

16. Identify and list size, type, and manufacturer of diffusers, grilles, registers, and all tested equipment. Use manufacturer's ratings on all equipment to make required.

17. In rooms requiring pressure or flow differentials between rooms, test and record the values obtained.

18. Include required velocity and test velocity, and required volume and test volume after adjustments of diffusers, grilles and registers.

19. In cooperation with the control manufacturer's representative, set adjustments of automatically operated dampers to operate as specified, indicated and/or noted. This contractor shall check all controls for proper calibration and list all controls requiring adjustment by control installers.

20. Adjust all diffusers, grilles and registers to minimize drafts in all areas.

21. Test duct systems for "dirty" filter condition by providing temporary resistance in ductwork, and then for "clean" filter condition.
E. Methods of Measurement

1. Air flow in ductwork
   a. Measure air flow in ductwork in the following manner and with Pitot tube and inclined gage manometer.

   b. To determine air flow in ducts, make a complete traverse using the above approved instruments. Locate traverse points at least four equivalent diameters from nearest transition, duct or other obstruction; where this is not possible, note as not being within this tolerance.

   c. Mark off the cross section of the duct into areas of equal proportions - maximum dimensions of 6 inches, not less than 16 readings nor more than 64—and insert the Pitot tube so as to be in the center of each area, and note the gage reading for each. For readings of 700 FPM or below, a micromanometer (1/4" gauge with .005" graduations) shall be used. The inclined gage manometer or magnehelic gage are not accurate at this low velocity and are therefore unacceptable.

   d. Read the static pressure and record the results at each traverse point.

2. Air flow from diffusers
   a. Measure air flow from diffusers with one of the following type instruments:

      1) Deflecting Vane Anemometer (Velometer).

      2) Cone type devices (if approved by engineer).

   b. Mark each diffuser tested at locations of readings on face or vane. Place the velocity meter inlet jet in the vena contracta of the face vanes of the diffuser. Make a minimum of six readings to determine average velocity in feet per minute. Make all future readings and check readings at the marked locations of each diffuser.

3. Air flow from grilles and registers
   a. Measure air flow from grilles and registers with one of the following type instruments:

      1) 4" Rotating Vane Anemometer

      2) Deflecting Vane Anemometer (Velometer)

      A cone type gathering device may be used if approved by Owner Representative.
b. Obtain the average anemometer reading by marking off the grille in sections, taking a reading in front of each section and averaging the results. Readings made by moving the instrument back and forth across the face of the grill or register are not acceptable. Use the manufacturer's published correction factors in determining the total cfm being discharged. Note that different factors must be used for supply grilles and return and exhaust grilles.

4. To determine static pressure in ductwork, plenum chambers, across filters or across coils, use the inclined gage in conjunction with a static pressure tip. Insertion of the tube end or the use of suction cups is not acceptable. Make measurements in areas considered to have a stabilized pressure. Preferably two or more readings should be taken.

5. It is the responsibility of this contractor to test motor amperage using the amprobe meter. Whenever possible take readings at motor terminals. If motor terminals are not accessible, take readings at motor starter box or control. Before final reading is taken, set fan drive or vanes in position of final operation. Do not take readings until motor has come up to maximum speed after startup. Take readings on all three legs of three phase motors.

6. Fan cfm should not be determined by using published fan ratings. Make Pitot traverse to determine total air quantity.

7. Only where it is not feasible to obtain velocity pressure traverses in the branch ducts to determine branch line volumes, may the sum of the individual diffuser volumes be used to ensure proper balancing for a given branch. After all diffusers on a given branch have been balanced to deliver volumes of air which are all in a constant relation to the actual design value (be it above or below the optimum point), readjust the branch line dampers to increase or decrease the entire branch duct volume. Then, retest individual diffusers to ensure that they are now delivering the designed amount of air according to their individual requirement.

8. Measure coil face velocities with a 4" rotating vane type anemometer. Test engineer must attach long handle to instrument and avoid blocking any air flow motion with body. Continuous movement across face of coil is not allowed. Make individual spot readings at set intervals to establish averages.

F. Conditions of Systems

1. It is the responsibility of this contractor to determine the total amount of air required to flow across cooling coils
during maximum load conditions. Balance the supply systems on full call for cooling.

2. Conduct all tests with supply, return and exhaust systems operating, and all doors, windows, etc., closed or under projected operating conditions.

3. Make final readings and settings with cooling coils operating (wet), in order that static pressure conditions shall be maximum.

4. Obtain total system air quantities and provisions for dirty filters by adjustment of the fan operating speeds.

5. Adjust the deflection pattern of all supply outlets to ensure proper and uniform air distribution throughout the areas served by such outlets.

6. Permanently mark all damper positions after air balancing is complete.

G. Outside and Return Air Quantities

1. Final balanced conditions include the setting of outside air quantities and return air quantities.

2. Set outside air quantities by adjusting the dampers as follows:
   a. Where possible, use direct air flow readings obtained by a duct traverse or by a 4" rotating vane anemometer across the outside air intake louver.
   b. When conditions of ductwork or installation would result in incorrect or erratic readings, use the temperature percentage method of calculation. If this method is used, temperature measurement must be by duct traverse.

H. The final balanced condition of the building includes the testing and adjustment of pressure conditions. In most cases the percentages of air introduced by supply system and exhausted by exhaust systems will provide for a pressurization of the building. Check these percentages before final completion of work to make sure of pressure conditions. Check these percentages before final completion of work to make sure of pressure conditions. Check front doors, exits, etc., for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions.

1.4 WATER BALANCE PROCEDURE

A. Complete the air balancing in accordance with design requirements prior to proceeding with water balancing. As mentioned under "AIR
BALANCE PROCEDURES", the following exact sequence need not be followed; however, all requirements shall be met.

B. It is the responsibility of the contractor to measure and balance the water systems using the following approved instruments and devices:

1. One set of pressure gages and fittings.
2. Dry bulb thermometer.
3. Wet bulb thermometer.
4. Thermocouple unit and thermocouples.
5. Set of balancing valve and/or cock adjustment wrenches.
6. Portable field flowmeter.

C. Preparation of Systems

1. Open all valves to full position, including coil stop valves; close bypass valves and open line balancing valves or cocks.
2. Remove and clean all strainers.
3. Examine water in system to determine if it has been treated and is clean.
4. Check pump rotation.
5. Check expansion tanks to make sure they are not airbound and that the system is full of water.
6. Check all air vents at high points of water systems to make sure they are installed properly and are operating freely. Make certain all air is removed from circulating system.
7. Set all temperature controls so that all coils are calling for full cooling. This should close all automatic bypass valves.
8. Check operation of automatic bypass valves.
9. Check and set operating temperature of heat exchangers to design requirements. Check chilled water supply and return temperatures.

D. Test and Balance Procedure

1. Set hot water and chilled water pumps to proper GPM delivery.
2. Adjust flow of chilled water.
3. Adjust flow of hot water through heat exchangers.
4. Check leaving water temperatures and system return water temperatures, and pressure drop through exchangers. Reset to correct design temperatures.

5. Check water temperature at inlet side of cooling coils, process equipment, and similar items. Note rise or drop of temperatures from source. Balance each chilled water coil, process equipment and similar items to meet design requirements. Where specified, use venturis and calibrated orifices with portable or permanent type flow meter to measure the water flow. If this equipment is not specified, obtain water balance by using the "Cv" of control valves as described in ASHRAE Guide.

6. Balance comfort chilled water equipment elements from 90 to 100 percent of design flow, and hot water heating elements from 70 to 100 percent of design flow.

7. Upon completion of flow readings and adjustments, mark all settings and record all data.

8. After making adjustments to coils, process equipment, and similar items, recheck flow rates at pumps and heat exchangers. Readjust if required.

9. Install test gages on each coil, process equipment, and similar item' then read pressure drop through each item at set flow rate on call for full cooling and full heating. Set pressure drop across bypass valves, where applicable, to equal full flow pressure drop directly through item of equipment.

10. Upon completion of flow readings and adjustments, mark all balancing valve settings, unless valve has "memory" feature.

11. Check and adjust leaving water temperatures from heat exchangers to meet design requirements.

12. Adjust the differential pressure valves (where used) for the chilled water systems to provide a minimum pump flow for satisfactory pump operation when the system control valves are at shutoff.

13. Using circulating water pump data sheet and water balance element test sheet, complete and record all data requirements indicated therein. Properly identify all systems and the locations of all individual readings. Check and record the following items at each cooling and heating element:
   a. Inlet water and air temperatures.
   b. Leaving water and air temperatures.
   c. Pressure drop of each piece of equipment.
d. Pressure drop across bypass valve.

e. Pump operating suction and discharge pressure and final T.D.H.

f. All mechanical specifications of pumps.

g. Rated and actual running amperage of pump motors.

h. Rated and actual voltage of pump motors.

14. Upon completion, prepare a neatly typed list of all items required by specifications, and include in the complete test and balance report.

1.5 FORMS FOR TEST AND BALANCE WORK

A. The following forms shall be provided by contractor in the balancing reports:

1. Duct Traverse Data Sheet

2. Diffuser and Grille Test Sheet

3. Air Moving Equipment Test Sheet

4. Exhaust Fan Test Sheet

5. Circulating Water Pump Data

6. Water Balance Test Sheet

END OF SECTION
SECTION 23 07 00

THERMAL INSULATION FOR HVAC AND PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 SCOPE

A. This specification covers furnishing and installation of thermal insulation for hot and cold surfaces as they occur in HVAC and plumbing systems. The materials used, the methods of application and finishes required are generally described herein.

B. Surfaces to be insulated are as given below and as indicated on the drawings.
   1. All air handling units, casings and drain pans.

1.2 CLASSIFICATION OF INSULATION

A. This specification is based on the Insulation Classifications:
   1. Class I - Low Temperature - Surfaces having temperatures of 0° to 75°F.

1.3 WORK AND MATERIAL INCLUDED

A. Insulation, where required, for all cold surfaces including hangers in HVAC Systems with all necessary auxiliary material and appurtenances.

B. Anti-sweat covering for final connections of equipment drain lines.

1.4 GENERAL CONDITIONS

A. All materials shall be received, kept in dry storage until ready for use, unpacked and distributed ready for application.

B. All insulated surfaces must be cleaned and dried before starting application.

C. No cements, adhesive or coatings shall be applied when ambient temperature is below 40°F.

D. Insulation system components of dissimilar metals shall be insulated from one another to prevent galvanic action.

E. When sprayed-on insulation or finishes are used, the surrounding area and all accessories shall be protected.
F. Insulation shall be applied in such a manner as to prevent air circulation between insulated surface and the enclosing insulation.

G. All insulation and auxiliary materials shall be fireproof or fire retardant.

H. All casings shall use board form insulation. Ducts 36" wide and less may be insulated with blanket type material, but only where such surfaces are in concealed spaces.

I. Surfaces to be insulated for different classes of insulation as defined in Section 1.2, above, are given below:

1. Class I - All casings, equipment and ductwork through which cold air passes. All Class I insulation shall have vapor barrier.

J. Under all conditions, insulation for personnel protection shall provide a surface temperature of not more than 150°F to a height of seven feet above the operating level.

K. Access doors, hand holes and removable panels shall be separately insulated and the surrounding insulation shall fit snugly around these removable pieces. The removable components shall have, wherever possible, insulation material completely enclosed in metal sheaths for protection in handling, and have surfaces flush with those of the surrounding insulation.

L. When nameplates are covered by insulations, the Contractor shall provide a duplicate nameplate which shall be affixed to the exposed insulation surface.

M. Weather protective coatings and finishes shall be applied immediately after insulation is installed and cements and adhesive are dry.

1.5 WORKMANSHIP AND MATERIALS

A. All materials and equipment shall be new and shall conform to the latest issue (at date of purchase) of industry standards and all applicable codes.

B. All work shall be performed by mechanics skilled in the related trades. Installation shall be done neatly in accordance with drawings and this specification.

C. Any accessories or appurtenances not specified or called for, but necessary to the satisfactory completion of installation, shall be provided without additional cost to the Owner.

D. Provide proper protection at all times against injury or damage resulting from work in handling and installing equipment,
materials, and accessories. Repairing and or replacing any damage to building or equipment as directed by the Owner shall be done at no additional cost to the Owner.

1.6 SCAFFOLDING

A. Provide all scaffolding, ladders and platforms required for complete installation. Such scaffolding and other temporary supports shall meet the standards of any applicable National, State or Local Safety Codes.

1.7 THICKNESS OF INSULATION

A. Insulation of thickness for various insulation materials shall be in accordance with values given in Table I below:

<table>
<thead>
<tr>
<th>Insulation Material</th>
<th>Type Surface</th>
<th>Thickness of Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0°-24°</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>Pipe to 4&quot;</td>
<td>1⅛&quot;</td>
</tr>
<tr>
<td></td>
<td>Over 4&quot;</td>
<td>2&quot;</td>
</tr>
<tr>
<td>Mineral Fibre</td>
<td>Pipe to 4&quot;</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Over 4&quot;</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Flat</td>
<td>--</td>
</tr>
</tbody>
</table>

Personal Protection - 1" Thick for Fluid Temperature to 350°F.

B. For flat surfaces having extended stiffeners the insulation thickness shall in no case be less than the depth of the stiffener flange plus 1/4".

1.8 INSULATION MATERIALS

A. For pipe fittings, valves and specialties, molded insulation shall be used. The following materials are acceptable:

1. Class I - Insulation (0° – 75°)
   a. Molded cellular polyurethane foam (1.5 – 2.5 lbs. density).
   b. Vapor Barriers
      1) Fire retardant, kraft paper reinforced aluminum foil.
      2) Mastic vapor barrier with glass fabric finish.
2. Class II - Insulation (100° - 250°F)
   a. Molded fibrous glass, slag or rock (5 - 7 lbs. density).
   b. Mineral wool insulating cement.
   c. Vapor Barriers same as in paragraph 1.8A.1.

B. For flat surfaces - ducts, AHU casings and equipment - in exposed areas, semi-rigid board insulation material shall be used. The following are acceptable materials:

1. Class I - Insulation (0° - 100°F)
   a. Fibrous glass, slag or rock semi-rigid board with factory assembled FSK vapor barrier (6 - 7 lbs. density), thermal conductivity K factor not greater than 0.25 BTU-in/hr/SF/°F at 100°F mean temperature, with flame spread of 25 and smoke developed rating of 50 when tested per ASTM E-84.
   b. Mineral wool insulating cement.
   c. Vapor barriers same as in paragraph 1.8A.1.

C. For flat duct surfaces in concealed areas where the duct width is 36" or less, blanket type insulation may be used. The following are acceptable materials

1. Class I and II Insulation (0° - 250°F)
   a. Fibrous glass, slab or rock flexible blanket enclosed in fire retardant, kraft paper reinforced, foil vapor barrier (1 lb. density minimum), thermal conductivity K factor not greater than 0.33 BTU-in/hr/SF/°F at 100°F mean temperature, with flame spread of 25 and smoke developed rating of 50 when tested per ASTM E-84.

D. Filler for joints, voids and cavities mineral wool (glass, slag or rock) (2 - 5 lbs. density).

E. Anti-Sweat Covering
   1. Flexible plastic insulation 3/4" thick.
   2. 3/4" fibrous glass with general purpose vapor barrier.

1.9 AUXILIARY MATERIALS

A. Adhesives, cements, coatings, liquid vapor barriers, mastic vapor barriers, joint sealer and weather proofing compounds shall be compatible with the basic insulation material, the temperature of the insulated surface and duty required. These items are to be
specifically manufactured for the particular duty to be performed and are to be used in the consistency supplied without the addition of thinners.

B. All adhesives, cements, vapor barriers or joint sealers shall be long-lived, non-oxidizing, non-hardening and proof against all normal atmospheric pollutants. They shall contain no natural rubber in their formulation.

C. Glass fabric shall be 20 x 20 mesh made of continuous fiber yarn.

D. Wire for holding insulation in place shall be copper or stainless steel. Banding material shall be 3/4" wide, 0.020 thick aluminum or 0.015" thick stainless steel.

E. Insulation fasteners for flat surfaces shall be impalement clips either cemented or welded to the metal surfaces. When cement held clips are used the adhesive shall be specifically formulated for the purpose. All fasteners shall be corrosion resistant.

1.10 APPLICATION FLAT SURFACE INSULATION

Class I and II insulation for flat surfaces shall be installed as described below:

A. Insulation of flat surfaces exposed to view shall be semi-rigid board with factory assembled vapor barrier on its outer surface.

1. Cut board insulation accurately and apply over clean, dry surfaces. All joints shall be tightly butted. Cut insulation to fit between stiffeners and secure to ductwork by impalement over metal fasteners spaced not more than 12" on centers. Install minimum of two rows of fasteners per duct side and a minimum of two fasteners per section of insulation. Secure insulation with round beveled washers for each fastener. Cut off excess spindle length. Set washers solidly into the insulation surface and seal with mastic vapor barrier cement or 3" x 3" (minimum size) vapor barrier patches to provide complete vapor barrier protection.

2. Pack all joints at stiffeners, standing seams and projecting angles with mineral fiber filler. Fill and level off all surface irregularities and voids with an application of mineral wood cement and seal with vapor barrier tape. Seal all joints between sections of vapor barrier with 4" wide reinforced tape to provide completely sealed vapor barrier envelope.

B. Insulation for equipment and apparatus shall follow general specifications set forth in Section 1.11A. in so far as vapor barriers seals, insulation thickness and other general requirements are given.
1. Insulation shall be applied directly to regularly, shaped equipment and wired or banded in place with vapor barrier applied or built-up as required.

2. Enclosures shall be so fabricated that they may be opened easily for inspection and maintenance of enclosed items.

1.11 FINISH OF INSULATED SURFACES

A. Indoor Finish

1. Concealed insulated surfaces require no additional finish than those given in Section 1.10.

2. All insulated surfaces exposed to view shall be finished with glass fabric lagged to vapor barrier. Coat surfaces with lagging adhesive. Imbed fabric in wet adhesive overlapping all edges at least 2 inches. Apply final coat of lagging adhesive over fabric at once.

3. Flat surfaces shall be finish with glass fabric as specified in Paragraph 1.11A.2., above.
SECTION 23 07 19

PIPING INSULATION—DUAL TEMPERATURE
APPLICATIONS SUB-ZERO TO 400°F

PART 1—GENERAL

1.1 GENERAL

A. Piping shall not be covered with insulation until approved and accepted by the Inspector.

B. All insulation materials shall be free of defects and shall be carefully applied in whole pieces. No broken pieces shall be accepted. All work not according to specifications shall be removed and replaced at the expense of the Contractor.

C. All piping shall be perfectly clean and dry before insulation is applied. The metal should then be primed with either a rust inhibiting paint or an asphalt mastic depending upon the temperatures involved.

1.2 THICKNESS

A. All piping shall be insulated with the proper thickness of insulation as shown in the drawings. Insulation thickness shall be determined by lowest temperature at which the piping normally operates.

B. Where welded pipe saddles are called for in the specifications the insulation shall be carried down over the saddles and covered with the same thickness of the outer layer of insulation.

C. Where piping is supported by structural members the insulation shall be extended not less than four times the specified insulation thickness in each direction, measured from junction of pipe with insulated support lug. Thickness of insulation over steel support shall be one-half that specified for piping. Thickness of insulation over support lugs to be the same of the specified for piping.

1.3 APPLICATION

A. Where single layer factory-wrapped insulation is used, application shall be made as received, with joints tightly butted and sufficiently buttered with specified joints sealer. Wrapping laps shall be brushed with specified sealer and pressed firmly in place.
B. Where single layer regular insulation is used, the insulation shall be applied to piping with butt joints staggered and all joints tightly butted and buttered with joint sealer. A finish shall then be applied if called for in the specifications.

C. On multiple layer insulation, the additional layer or layers shall be applied with side and end joints staggered over joints of preceding layer.

D. Only outer layer joints of multiple-layer applications shall be buttered with specified joint sealer before installation. The joints shall be drawn together so that only a very thin vapor seal separates the section of insulation.

E. Service temperature limits of joints sealer shall be within range of cycling temperature to which it is expose.

F. Insulation shall be applied with all joints fitted to eliminate voids. Large voids shall not be filled with vapor seat coating, but eliminated by refitting or replacing insulation.

G. Where piping is subject to excessive vibration, the bore of the inner layer shall be coated with a thin application (to fill surface cells only) of specified bore coating, and allowed to dry before application of insulation to piping.

H. Single and outermost layers of pipe insulation shall be secured in place with stainless steel insulation strap on 9” centers.

I. After specified thickness of insulation has been installed, a finish shall be applied if called for in the specifications.

J. Expansion and contraction joints shall be installed in both horizontal and vertical straight run piping when piping will be subjected to temperatures which dictate the necessity of such joints.

1. Joints shall be packed tightly with cushioning material.

2. When expansion and contraction joints are required, expansion and contraction should be provided by and in the flange cover of flanged joints when they occur in the line.

K. Insulation on flanges, valves and other fittings shall consist of prefabricated fitting covers of the same material and thickness specified for pipe insulation.

1. Fitting covers shall be applied in the same manner as pipe insulation. Stainless steel insulation strap shall be so located that maximum strength and securement shall be obtained. Fitting filters are not necessary, provided all joints are properly sealed.
2. Protruding metal parts (such as valve stems) shall be thoroughly sealed.

3. Hangers shall be on the outside of the insulation and shall not be in contact with the pipe. Curved metal shields shall be used between the hangers and the bottom of the insulation. Shield and hanger spacing shall be designed to limit the compressive stress between hanger and insulation to 35 psi.

4. Outer surface of fitting covers shall be reinforced and finished in the same manner as specified for pipe insulation. Care shall be exercised that reinforcing cloth overlaps connecting pipe insulation a distance of not less than six (6) inches.

   a. Indoors
      
      1) Regular unwrapped pipe insulation installed indoors shall not be finished unless called for in the specifications.
      
      2) Where a coating is called for in the specification if shall be applied according to the following:
         
         a) Glass - Fabric and Aluminum Jacketed (Factory Applied) pipe insulation may be used without additional finish.
         
         b) Canvas and Lagging Cement-One layer of rosined paper may be used to cover bonding. Apply canvas using lagging cement, taking care to remove wrinkles and cement all edges, locate seams where least noticeable.
         
         c) Asphalt impregnated felt shall be secured over the insulation by corrosion resistant bands with ends lapped.
         
         d) Asphalt Weather Coat Materials. Regular or wrapped insulation shall be first tack-coated with fibrated asphalt cut-back using no less than two gallons per 100 square feet. Into this is a layer of asphalt impregnated glass cloth shall be embedded, over lapping all ends, and then in other coating of no less than four gallons per 100 square feet of cut-back applied.
         
         e) Metallic foil or light gauge sheet metal Coat Material Metallic foil or light gauge sheet metal shall be applied over the insulation. Provide a minimum 3" overlap and fasten snugly with
corrosion resistant bands. Insulation shall first be given a thin coat of cut-back.

3) Outdoors

a) Glass - Fabric and Aluminum Jacketed (Factory applied) pipe insulation may be used without additional finish and approved by the Inspector.

b) Regular insulation shall be protected as follows:

1- After specified thickness of equipment insulation has been installed, an approved coating shall be sprayed, brushed, or troweled on to a minimum thickness. While coat is still tacky, an open weave (10 x 10 mesh) glass membrane shall be laid smooth and thoroughly embedded in coating. Care must be exercised that weave does not rupture and that cloth is overlapped approximately three inches (3") to provide strength at joint equal to that maintained elsewhere.

2- Before surface becomes dry to the touch, a second coating shall be sprayed, brushed, or troweled over the reinforcing cloth to a uniform thickness not less than 1/8 inch thick, with a smooth, unbroken surface, and allowed to dry.

3- Application of coating shall be built up in uniform manner to prevent uneven contraction and tendency toward surface cracks. When spraying, care should be taken that air is directed at sufficient pressure to obtain maximum atomization without pack-working of surface owing to excessive velocity. Slugs shall be removed from surface immediately.

4- Metallic foil or light gauge sheet metal Coat Materials, Metallic foil or light gauge sheet metal shall be applied over insulation. Provide a 3" minimum overlap and fasten snugly with corrosion resistant bands. Insulation shall first be given a thin coating of cut-back.

5- Flashing. On equipment located outdoors, it is imperative that proper flashing materials and methods be used at nozzles, manholes and other projections, as well as the junction of horizontal and vertical installations.
6- Painting. When asphaltic materials are specified for the weathercoat and paint is desired, it may be done as follows (usually by separate contract).

7- As soon as asphalt surface has dried, the surface shall be painted with asphalt base aluminum paint.

c) Piping in Equipment Rooms

1- Provide an 8 ounce canvas jacket protection covering over insulation in machine rooms, in air unit rooms or in any place where insulation is subject to physical damage.

PART 2 – PRODUCTS

Not Used

PART 3 – EXECUTION

Not Used

END OF SECTION
SECTION 23 09 00

INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01

1.2 SUMMARY

A. Related Sections include the following:
   1. For HVAC sequence of operation refers to Project Drawings H4-01 and H4-02.
   2. Section 26.05.00 “Electrical General Provisions”
   3. Section 13.05.41 “Seismic Control”
   4. Section 26.05.33.26 “Cable Trays”
   5. Section 25.31.00 “Control and Instrumentation System”

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. BACNET: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:
   1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.

6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   a. Water Temperature: Plus or minus 1 deg F.
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F.
   e. Ducted Air Temperature: Plus or minus 1 deg F.
   f. Outside Air Temperature: Plus or minus 2 deg F.
   g. Dew Point Temperature: Plus or minus 3 deg.
   h. Temperature Differential: Plus or minus 0.25 deg F.
   i. Relative Humidity: Plus or minus 5 percent.
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg.
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product
data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
4. Details of control panel faces, including controls, instruments, and labeling.
5. DDC System Hardware:
   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
6. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
7. Controlled Systems:
   a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
   b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
   c. Written description of sequence of operation including schematic diagram.
   d. Points list.

1.6 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with BACNET.

B. Qualification Data: For Installer.

C. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.

D. Field quality-control test reports.
1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
2. Interconnection wiring diagrams with identified and numbered system components and devices.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

1.9 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 equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate equipment with Section 253100 "Control and Instrumentation System" to achieve compatibility of communication interfaces.

D. Coordinate equipment with Section 262416 "Panelboards" to achieve compatibility with starter coils and annunciation devices.

E. Coordinate equipment with Section 262419 "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

A. Manufacturers:
   1. Honeywell
   2. KMC Controls
   3. Distech Controls

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.2 DDC EQUIPMENT

A. Operator Workstation: One PC-based microcomputer with minimum configuration as follows:

   1. Motherboard: With 8 integrated USB 2.0 ports, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
   2. Processor: Intel Core i7-2.0 MHz.
   3. Random-Access Memory: 8 GB.
   5. Monitor: 19 LCD color.
   7. Hard-Disk Drive: 800 GB.
   8. CD-ROM Read/Write Drive: 48x24x48.
   10. Uninterruptible Power Supply: 500 kVA.
11. Operating System: Microsoft Windows XP Professional with high-speed Internet access.
   a. BACNET Compliance: Workstation shall use BACNET protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

12. Printer: Color, ink-jet type as follows:
   a. Print Head: 4800 x 1200 dpi optimized color resolution.
   b. Paper Handling: Minimum of 100 sheets.
   c. Print Speed: Minimum of 17 > ppm in black and 12 ppm in color.

13. Application Software:
   a. I/O capability from operator station.
   b. System security for each operator via software password and access levels.
   c. Automatic system diagnostics; monitor system and report failures.
   d. Database creation and support.
   e. Automatic and manual database save and restore.
   f. Dynamic color graphic displays with up to 10 screen displays at once.
   g. Custom graphics generation and graphics library of HVAC equipment and symbols.
   h. Alarm processing, messages, and reactions.
   i. Trend logs retrievable in spreadsheets and database programs.
   j. Alarm and event processing.
   k. Object and property status and control.
   l. Automatic restart of field equipment on restoration of power.
   m. Data collection, reports, and logs. Include standard reports for the following:
      1) Current values of all objects.
      2) Current alarm summary.
      3) Disabled objects.
      4) Alarm lockout objects.
      5) Logs.
   n. Custom report development.
   o. Utility and weather reports.
   p. Workstation application editors for controllers and schedules.
   q. Maintenance management.

14. Custom Application Software:
   a. English language oriented.
b. Full-screen character editor/programming environment.
c. Allow development of independently executing program
modules with debugging/simulation capability.
d. Support conditional statements.
e. Support floating-point arithmetic with mathematic
functions.
f. Contains predefined time variables.

B. Diagnostic Terminal Unit: Portable notebook-style, PC-based
microcomputer terminal capable of accessing system data by
connecting to system network with minimum configuration as
follows:

1. System: With one integrated USB 2.0 port, integrated Intel
   Pro 10/100 (Ethernet), integrated audio, bios, and hardware
   monitoring.
2. Processor: Intel Core i7, 2.0 MHz.
3. Random-Access Memory: 4 GB.
4. Graphics: Video adapter, minimum 1024 x 768 pixels, 64-MB
   video memory.
7. Hard-Disk Drive: 600MB.
8. CD-ROM Read/Write Drive: 48x24x48.
9. Pointing Device: Touch pad or other internal device.

C. Control Units: Modular, comprising processor board with
programmable, nonvolatile, random-access memory; local operator
access and display panel; integral interface equipment; and
backup power source.

1. Units monitor or control each I/O point; process
   information; execute commands from other control units,
   devices, and operator stations; and download from or upload
to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of
   network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
   d. Software applications, scheduling, and alarm
      processing.
   e. Testing and developing control algorithms without
      disrupting field hardware and controlled environment.
3. Standard Application Programs:
   a. Electric Control Programs: Demand limiting, duty
      cycling, automatic time scheduling, start/stop time
      optimization, night setback/setup, on-off control with
      differential sequencing, staggered start, antishort...
cycling, PID control, DDC with fine tuning, and trend logging.

b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.

c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.

d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.

e. Remote communications.

f. Maintenance management.

g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

5. BACNET Compliance: Control units shall use BACNET protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

D. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.

2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.

b. Discrete/digital, analog, and pulse I/O.

c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. BACNET Compliance: Control units shall use BACNET protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

E. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.

2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.


7. Universal I/Os: Provide software selectable binary or analog outputs.

F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.3 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72 hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms.
Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.

3. **BACNET Compliance**: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in BACNET. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

4. **Indoor Enclosure**: Dustproof rated for operation at 120 deg F.

5. **Outdoor Enclosure**: Waterproof rated for operation at 150 deg F.

### 2.4 ALARM PANELS

**A.** Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

**B.** Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. **Alarm Condition**: Indicating light flashes and horn sounds.
2. **Acknowledge Switch**: Horn is silent and indicating light is steady.
3. **Second Alarm**: Horn sounds and indicating light is steady.
4. **Alarm Condition Cleared**: System is reset and indicating light is extinguished.
5. **Contacts in alarm panel** allow remote monitoring by independent alarm company.

### 2.5 ELECTRONIC SENSORS

**A.** Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

**B.** RTDs and Transmitters:

1. **Manufacturers**
   a. Minco
   b. Bourns
   c. Omega
   d. Rosemount

2. **Accuracy**: Plus or minus 0.2 percent at calibration point.
3. **Wire**: Twisted, shielded-pair cable.
4. **Insertion Elements in Ducts**: Single point, 8 inches and 18 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
5. **Averaging Elements in Ducts**: 18 inches long, rigid; 24 inches long, rigid; 48 inches long, rigid; 24 feet long,
flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. length as required.

6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches.

C. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:
   a. Vaisala
   b. General Eastern Instruments
   c. Rotronic Instrument Corp.

2. Accuracy: 2 percent full range with linear output.

3. Room Sensor Range: 20 to 80 percent relative humidity.

4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

D. Pressure Transmitters/Transducers:

1. Manufacturers:
   a. Ashcroft
   b. Setra
   c. Modus
   d. Rosemount

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
   a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0- to 0.25-inch wg.
   d. Duct Static-Pressure Range: 0- to 5-inch wg.

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure and tested to linear output 4 to 20 mA.

5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.6 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.7 AIR FLOW MEASURING

A. Pitot tube velocity pressure air flow measuring
   1. Manufacturer: Air Monitor Corporation

B. Thermal Dispersion Airflow Measuring.
   1. Manufacturer: Ebtron, Inc.

2.8 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
   1. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
2. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf.

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
2. Dampers: Size for running torque calculated as follows:
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
   e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.

4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
5. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
8. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
9. Temperature Rating: 40 to 104 deg F.
10. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
11. Run Time: [12 seconds open, 5 seconds closed] [30 seconds] [60 seconds] [120 seconds].
2.9 CONTROL VALVES

A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

B. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
   a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
   b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:
   b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
   c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conditioned power supply is available to control units and operator workstation.

B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.
3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 60 inches above the floor.

   1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

D. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

E. Install labels and nameplates to identify control components.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."

B. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Section 270000 "Communications Systems."

   1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   2. Install exposed cable in raceway.
   3. Install concealed cable in raceway.
   4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including
connections, and to assist in field-testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
5. Check temperature instruments and material and length of sensing elements.
6. Check control valves. Verify that they are in correct direction.
7. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
   a. Check analog inputs at 0, 50, and 100 percent of span.
   b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
   c. Check digital inputs using jumper wire.
   d. Check digital outputs using ohmmeter to test for contact making or breaking.
   e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistance source.
5. Flow:
   a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
   b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
   a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
   b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended
procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

END OF SECTION
SECTION 23 21 14
PRESSURE GAUGES AND THERMOMETERS
FOR CHW, CTW AND RWH SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pressure gauges and Pressure gauge taps.

B. Thermometers and thermometer wells.

1.2 REFERENCES

A. ASME B40.1 - Gauges - Pressure Indicating Dial Type - Elastic Element.


PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Manufacturer: Ashcroft Model 1279.

B. Other acceptable manufacturers offering equivalent products.
   1. USG - Solfrunt Model 1981.
   2. Weksler Instruments #BA14P
   3. Weis 4UGE-2

C. Gauge: ASME B40.1, with 316SST bourdon tube, bronze movement, brass socket, black scale on white background.
   1. Case: Polypropylene, phenol or aluminum.
   2. Bourdon Tube: Type 316 stainless steel.
   3. Dial Size: 4½ inch (114 mm)
   4. Mid-Scale Accuracy: One percent.
   5. Scale: Psi.
2.2 PRESSURE GAUGE TAPPINGS

A. Ball Valve:

1. Manufacturers:
   
   a. Jamesbury, Model 356.
   
   b. Jenkins, F.G. 1336.
   
   c. Apollo, Model 96-101.
   
   d. Substitutions: Not permitted.

2. Stainless Steel, 1/4 inch (6 mm) NPT for 250 psi (1720 kPa).

B. Pulsation Damper:

1. Manufacturers:

   a. Ashcroft, Model 25-11065.
   
   b. Weksler, Model RS-7.
   
   c. Substitutions: Not permitted.

2. Pressure snubber, stainless steel with 1/4 inch (6 mm) NPT connections.

2.3 STEM TYPE THERMOMETERS

A. Manufacturer: Jay Instrument, Model 9-200-36E-090.

B. Other acceptable manufacturers offering equivalent products.

   1. Weiss 9VU-5.
   

C. Thermometer: ASTM E1, adjustable angle, red appearing mercury,
   lens front tube, cast aluminum case with enamel finish, cast
   aluminum adjustable joint with positive locking device.

   1. Size: 9 inch (229 mm).
   
   2. Window: Clear glass or Lexan.
   
   3. Stem: Brass, 3/4 inch (20 mm) NPT, 3 1/2 inch (89 mm).
   
   4. Accuracy: ASTM E77 2 percent.

   5. Calibration: Degrees F.
2.4 DIAL THERMOMETERS

A. Manufacturer: Ashcroft Model 50 E1-60E.

B. Other acceptable manufacturers offering equivalent products.
   1. USG, Model 6530.
   2. Weksler, Model AU06.

C. Thermometer: ASTM E1, stainless steel case, adjustable angle, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
   1. Size: 5 inch (127 mm) diameter dial.
   2. Lens: Clear glass or Lexan.
   3. Accuracy: 1 percent.
   4. Calibration: Degrees F.

2.5 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.6 TEST PLUGS

A. Test Plug:
   1. Manufacturers:
      b. Sisco P/T Plugs, Model BNE-025.
      c. Substitutions: Not permitted.
   2. 1/4 inch (6 mm) NPT or 1/2 inch (13 mm) NPT brass fitting and cap for receiving 1/8 inch (3 mm) outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F (93 degrees C).

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install pressure gauges where shown on the drawings and at every item or equipment receiving or producing flow in or from the system.
B. Install one pressure gauge per pump, with taps before strainers and on suction and discharge of pump; pipe to gauge.

C. Pressure gauges subject to vacuum conditions, such as pump suctions, shall be rated for vacuum service.

D. Install pressure gauges with pulsation dampers. Provide 1/4 inch (6.35 mm) ball valve to isolate each gauge. Extend nipples to allow clearance from insulation.

E. Install thermometers as shown on the drawings and on the inlet and outlet of every item or equipment where the fluid is either heated or cooled.

F. Thermometer scale ranges shall be:
   1. For Chilled Water: 0 to 100 °F.
   2. For Condenser Water: 0 to 160 °F.
   3. For Reheat Water: 20 to 200 °F.

G. Install thermometer sockets adjacent to controls systems thermostat, transmitter, or sensor sockets.

H. Provide thermometer with a brass or stainless steel well, installed in a threaded coupling into the pipe being measured.

I. Thermowell insertion length shall be not less than one half of the pipe diameter. Thermometer stem length shall be sized accordingly.

J. Provide instruments with scale ranges selected according to service such that they operate at midrange of full scale during normal operation of the system.

K. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.

L. Thermowell with lagging extension shall be used in all insulated piping applications.

M. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.

N. Locate test plugs adjacent to pressure gauges and pressure gauge taps where indicated on drawings.

END OF SECTION
SECTION 23 31 00

DUCTWORK, CASINGS AND ACCESSORIES

PART 1 - GENERAL

1.1 WORK INCLUDED

A. Ductwork and accessories as required by the contract documents.

1.2 RELATED WORK

A. Refer to other Division 23 sections for exterior insulation of ductwork; not work of this section.

B. Refer to other Division 23 sections for fans and air handling units; not work of this section.

C. Refer to other Division 23 sections for testing, adjusting, and balancing of ductwork systems; not work of this section.

1.3 QUALITY ASSURANCE

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

B. Installer Qualifications: Firms with at least five years of successful installation experience on projects with ductwork systems similar to that required for this project.

C. Codes and Standards:

1. SMACNA Standards: Comply with the latest editions of SMACNA's Standards, for fabrication and installation of ductwork and accessories.

2. ASHRAE Standards: Comply with the latest editions of the ASHRAE Handbooks for fabrication and installation of ductwork, and accessories.


4. ASTM:

   a. A526: Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process, Commercial Quality.


   c. B370: Copper Sheet and Strip for Building Construction.
5. UL Compliance: Standard 555 "Fire Dampers and Ceiling Dampers."

1.4 SUBMITTALS

A. Product Data: Submit manufacturer's product data for ductwork materials and products.

B. Shop Drawings: Submit scaled layout drawings of ductwork and fittings including, but not limited to, duct sizes, locations, elevations, and slopes of horizontal runs, wall and floor penetrations, and connections. Show interface and spatial relationship between ductwork and proximate equipment. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced. As a minimum include the following:

1. Overall two-line duct layout, dimensioned with respect to building column centerlines and connections to equipment.

2. Elevations and sections as required to show clearances, methods of support, and details of installation.

3. Distance from bottom of ducts to finished floor.

4. Location of duct supports and sway bracing.

5. Details of duct supports, including hanger locations, hanger type, connections to duct and to building, auxiliary steel, etc.

6. Location and Details of Auxiliary Equipment, including:
   a. Grilles
   b. Registers
   c. Diffusers
   d. Extractors
   e. Volume Dampers
   f. Fire Dampers
   g. Splitter Dampers
   h. Access Doors
   i. Turning Vanes
   j. Thermometer and Pressure Sensing Connections
k. Test Openings for Pitot Readings
l. Control Instruments
m. Duct Drains
n. Flexible Connections

C. Record Drawings: At project closeout, submit record drawings of installed ductwork and ductwork products, in accordance with the Contract Documents.

D. Maintenance Data: Submit maintenance data and parts lists for ductwork materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual; in accordance with the Contract Documents.

1.5 DELIVERY, STORAGE AND HANDLING

A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings.

B. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

C. Store stainless steel ductwork and accessories on wood.

PART 2 - PRODUCTS

2.1 DUCTWORK MATERIALS

A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.

B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A527, lockforming quality; with G90 zinc coating in accordance with ASTM A525; and mill phosphatized for ductwork to be painted.

C. Stainless Steel Sheet: ASTM A167; Type 302, 304, or 316; No. 4 finish where exposed to view in occupies spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.

E. Copper Sheet: ASTM B370; H00 temper, except where 060 temper is required for unusual forming.

2.2 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Provide miscellaneous materials and products where not otherwise indicated, of the type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

B. Fittings: Provide radius type fittings fabricated of multiple sections with maximum 15 deg. change of direction per section. Unless specifically detailed otherwise, use 45 deg. laterals and 45 deg. elbows for branch takeoff connections. Where 90 deg. branches are indicated, provide conical type tees.

C. Duct Liner: Fibrous glass, complying with Thermal Insulation Manufacturers Association (TIMA) AHC-101; of 1 inch thick.

D. Duct Liner Adhesive: Comply with ASTM C916 "Specifications for Adhesives for Duct Thermal Insulation."

E. Duct Liner Fasteners: Comply with SMACNA HVAC Duct Construction Standards, Article S2.11.

F. Duct Sealant: Non-hardening, non-migrating mastic or liquid elastic sealant, type applicable for fabrication/installation detail, as compounded and recommended by manufacturer specifically for sealing joints and seams in ductwork.

G. Duct Cement: Non-hardening, non-migrating mastic or liquid neoprene based cement, type applicable for fabrication/installation detail, as compounded and recommended by manufacturers specifically for cementing fitting components, or longitudinal seams in ductwork.

H. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

1. For exposed stainless steel ductwork, provide matching stainless steel support materials.

2. For copper ductwork, provide, bronze or brass support materials, except where materials are electrolytically separated from ductwork.

3. For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.

I. Flexible Ducts: Either spiral-wound spring steel with flameproof vinyl sheathing, or corrugated aluminum; complying with UL181.
Where installed in unconditioned spaced other than return air plenums, provide 1 inch thick continuous flexible fiberglass sheath with vinyl vapor barrier jacket.

J. Underslab Ducts: For ductwork placed in concrete slabs, or under slabs on grade, fabricate ductwork of one of the following materials:

1. Galvanized Steel.
2. Vinyl Chloride Coated Steel.
3. Stainless Steel.

2.3 FABRICATION

A. Shop fabricate ductwork in 4, 8, 10 or 12-ft lengths, unless otherwise indicated or required to complete runs. Preassemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.

B. Shop fabricate ductwork of gages and reinforcement comply with SMACNA Duct Construction Standards, latest edition.

C. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to associated duct width; and fabricated to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 30 deg. for contracting tapers and 20 deg for expanding tapers.

D. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible.

E. Fabricate ductwork with duct liner in each section of duct where indicated. Laminate liner to internal surfaces of duct in accordance with instructions by manufacturers of lining and adhesive, and fasten with mechanical fasteners.

2.4 BLACK STEEL-WELDED DUCTWORK

A. Construct ductwork of 12 gage black iron with all joints air and water tight.

B. Continuously weld longitudinal joints.

C. Make transverse joints of angle flanges with gaskets.
D. Secure bracing and joint angles to ducts and casing by riveting or tack welding at corners and along the angles at intervals of not more than 6 inches.

E. Seal transverse joints with rivets at corners and along the joints at intervals of not more than 6 inches.

F. Provide access doors of 12 gage as shown on drawings.

G. Pitch the duct toward inlet openings for a distance of up to 5 ft - 0 in. beyond the last inlet.

H. Provide valved drain pockets at the base of each vertical change in direction of the duct. Pitch horizontal duct rungs toward the drain pockets.

I. Fabricate ductwork with standing longitudinal and transverse seams constructed so as to present a smooth unobstructed air passage within the duct and to assure that the duct fasteners are kept out of the air stream.

J. Seal all ductwork, joints, seams and penetrations completely airtight with sealing compound.

K. Where, during fabrication, handling or erection, the protective duct coating becomes damaged, restore it with sealing compound.

2.5 COPPER DUCTWORK

A. Fabricate copper ductwork in accordance with the SMACNA Standards. Construct bracing angles and bars of red brass.

B. Locate all longitudinal joints above the center line of the duct. Solder or braze all joints watertight.

2.6 STAINLESS STEEL DUCTWORK

A. Construct all ductwork components including external bracing, dampers, turning vanes, access doors, hardware, operating rods, welding rods, accessories and all other devices in the air stream of Type 316 stainless steel with the same gauges, bracing, hangers and other construction details as for Galvanized Steel ductwork except for the modifications listed below.

B. Materials:


C. Construction:

1. Longitudinal Seams: Continuously welded air tight.

2. Transverse Joints: "Van Stone" flanges formed by returning ends of duct sections a minimum of 3/4" and compressing between minimum 1¼" x 1¼" x 3/16" companion angles tack welded together maximum 6 inches on centers; bolt joints on 6 inches maximum centers.

2.7 FIBERGLASS DUCTWORK

A. Resin bonded fiberglass, rigid, impact-resistant, slip coupling joint with air tight gasket.

B. Fittings: 90 deg. elbows, 45 deg. lateral, Tee, reducers and volume dampers.

C. Hangers: Spaced in accordance with manufacturer's recommendations.

D. Duct Thickness: 1/8" up to 12", 3/16" thick 13" to 26" and 1/4" thick 27" to 44".

DuVerre Inc. - Atlas 382-05
Atlas Mineral Products Co.
Apex Fiber-Glass Products

2.8 CASINGS

A. Single Wall:

1. Single wall casings shall be fabricated of rigid panel sections, jointed together by gasketed companion angle flanges, bolted on not over 12" centers. Panels shall be stiffened by angles reinforcing or standing seam construction. All joints shall be made air and water tight by gasketing, sealing and caulking as required.

2. Casing wall and ceiling shall be braced and stiffened to carry a 175 lb. man's weight without noticeable deflection. The side wall of the casing shall be mounted on a 6" high concrete curb. All sides shall be securely fastened to curb with 2½" x 1/4" base angles, gasketed and expansion bolted to curb.

3. Construct all portions of casing of galvanized steel with cadmium plated rivets, screws and bolts in accordance with the latest recommendations and details of ASHRAE and SMACNA, for the pressure imposed on the particular casing.

B. Double Wall:

1. Double wall insulated panels fabricated of galvanized steel sheets formed to completely enclose 1½" thick rigid fireproof
6 lb. density mineral fiber insulation cemented to the sheet metal. Weld panels at 2" intervals and seal seams with permagum or Minnesota Mining Co. Type 800 Sealing Compound to make a vapor tight enclosure.

2. Construct all portions of casings of galvanized steel with cadmium plated rivets, screws and bolts.

3. Normally house all air treatment equipment within the casing, but where the equipment must form a portion of the casing wall, insulate equipment with 1½" thick 6 lb. density fiberglass and cover the insulation with a protecting panel of 18 gauge galvanized steel for the thickness of the penetration. Provide access openings in the exterior panel for servicing of the equipment and for observation. Face the openings with galvanized steel for the thickness of the penetration.

4. Panel Joints and Finishes:
   b. At Concrete Base: Continuous galvanized steel base channel.
   c. Butt Joints: Formed tees and hemmed finishing strips.
   d. Fastener Spacing: Rivets, screws and bolts; maximum 6" centers.
   e. Welds: Maximum 2" centers.

5. Caulk all joints and openings air and water tight. Where pipes are required to penetrate the panels, provide 22 gauge galvanized steel sleeve; pack space between sleeve and pipe with fiberglass insulation. On outside of panel, provide 1/4" rubber gasket and 10 gauge gasket ring. Seal all openings with silicone sealer G.E. Sil-Proof or Minnesota Mining Co. Type 800 Sealing Compound.

6. Panel Connections:
   a. Discharge Side of Supply fans: High pressure double wall type.
   b. All others: Standard double wall type.

2.9 DRAIN PANS AND TROUGHS

A. Construct drain pans in casings and ducts of 12 ga. stainless steel with all seams continuously welded water-tight. Pitch all surfaces to minimum 1½ in. steel drain coupling welded to the pan.
B. Construct drain pans the entire width of casing or duct in which they are installed and extending continuously in direction of air flow from a point, a minimum of 6 in. upstream of the coil assembly to 12 in. beyond the leaving edge of the coil or eliminator. Pan depth, 6 in. in casing, 3 in. in duct. Coat the interior of the drain pan with Koppers Bitumastic Tank Solution.

C. Install galvanized iron, bearing plates or beams in the drain pan to support the weight of the coils. Transmit the weight through bottom of the drain pan directly to 2" hardwood blocks bearing on the concrete pad.

D. Provide 2 in. cellular glass insulation beneath the drain pans.

E. Provide intermediate drain troughs at each tier of stacked cooling coils with a minimum 1¼ in. stainless steel pipe drain line or lines to the main drain pan.

F. Construct troughs of 16 ga. stainless steel, 2 in. wide and 1½ in. deep extending the length of the coil bank.

G. Locate the troughs so that condensate from the coil drains into it, so that air flow does not impinge on the water surface.

H. Pitch the troughs to the drain connections located at the low points.

2.10 ELIMINATORS

A. Construct 24 ga. galvanized steel moisture eliminators immediately downstream of all cooling coils and intermediate drain troughs in built up casings.

B. Construct the eliminators to provide three changes of direction for the air stream. Provide projections at each change of direction to prevent carryover of water droplets that impinge on each blade and to facilitate draining into drain pan. Provide intermediate bracing to prevent vibration and distortion of the blades.

C. Construct all fasteners and supports of galvanized steel.

2.11 CHIMNEY - PRE-FABRICATED - TYPE C-1

A. Double wall with air space including all required fittings, accessories and supports to make a complete installation.

B. Aluminum alloy inner wall and galvanized steel outer wall.

C. Acceptable Manufacturer:
   - Metalbestos Products - Model QC. (10" diameter and above)
   - Model RV (below 10" diameter)
2.12 CHIMNEY - PRE-FABRICATED - TYPE C-2
A. Double wall with air space including all required fittings, accessories and supports to make a complete installation.
B. Stainless steel inner wall and aluminized steel outer wall.
C. U.L. listed.
D. Acceptable Manufacturer: Metalbestos Model H.

2.13 CHIMNEY - PRE-FABRICATED - TYPE C-3
A. Double wall insulated including all required fittings, accessories and supports to make a complete installation.
B. Stainless steel outer and inner walls.
C. U.L. listed.
D. Acceptable Manufacturer: Metalbestos Model SS.

2.14 BOILER BREECHING
A. Minimum 12 ga. black welded steel breeching, including gas tight end cleanout, expansion joint, flange connections to boiler and smoke stack.
B. Breeching shall be supported in a manner so as not to create any stress or strain on the boiler flue gas outlet or the smoke stack.

2.15 BOILER STACK - SHOP FABRICATED
A. Minimum 10 ga., black welded steel stub stack, counter flashing skirt, gas tight cleanout, flange breeching connection and 1½ in. drain coupling welded to bottom of stack. Field weld flashing skirt continuously to stack.
B. Stack shall be supported on 3 x 3 x 1/4 in. angle flange welded to stack and bolted to roof structural framing.
C. Stack height shall conform to the local code.

2.16 BOILER STACK - PREFABRICATED
A. Prefabricated sectional type stack with an insulated refractory lined wall, including all required installation accessories.
B. Below the roof the stack shall have a 22 gauge aluminized steel jacked with a connection for the boiler breeching. The stack shall have a clean-out and drain located near the boiler room floor.
C. Above the roof the stack shall have a 11 gauge galvanized welded steel jacket and a flashing and counter-flashing section at the roof.

D. Acceptable Manufacturer:

   Flinkote Co.
   Van-Packer Products

2.17 SOUND ABSORBERS – TYPE SA

A. Construction:

   1. Outer Casing: 18 gauge, minimum, galvanized steel, properly braced.
   2. Inner Face: 24 gauge, minimum, perforated galvanized steel.
   3. End Connections: Continuously welded galvanized structural steel flanges, minimum 1" x 1" x 1/8", matching the flanges specified for the connecting ductwork.
   4. Sound Absorbing Material: Inorganic glass or mineral fiber faced to prevent erosion and complying with the latest smoke and flame requirements of the NBFU.
   5. Pressure Rating: To operated without distortion of air leakage with an internal air pressure of 8" w.g.

B. Certification: Certification of unit acoustical performance and air flow capacities at maximum pressure loss to be submitted by an independent recognized testing laboratory for production units selected at random.

C. Acceptable manufacturers:

   Industrial Acoustical Co., Inc.
   Koppers Co., Inc. "Aircoustat"
   Aerocoustic Corp.

2.18 DAMPERS

A. Low Pressure Manual Dampers: Provide dampers of single blade type or multiblade type, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

2.19 FIRE AND SMOKE DAMPERS

A. Fire Dampers: Provide fire dampers, of types and sizes indicated. Construct casings of 10 gauge galvanized steel. Provide fusible link rated at 160 to 165 deg. F (71 to 74 deg. C) unless otherwise indicated. Provide damper with positive lock in closed position, and with the following additional features:
1. Damper Blade Assembly: Curtain type
2. Blade Material: Steel, match casing

B. Fire/Smoke Dampers: Fire/smoke dampers, of types and sizes indicated. Construct casings of 10 gauge galvanized steel. Provide fusible link rated at 160 to 165 deg. F (71 to 74 deg. C) unless otherwise indicated. Provide a frangible link containing explosive charge, connected in series with fusible link. Provide stainless steel spring loaded leakage seals in sides of casing, and 36" long wires leads for connecting smoke link to smoke detector, and the following additional features:

1. Damper Blade Assembly: Multi-blade type.

C. Motor-Driven Fire/Smoke Dampers: Provide motor-driven fire/smoke dampers in types and sizes indicated, with casing constructed of 10 gauge galvanized steel, fusible link 160 to 165 deg. F (71 to 74 deg. C), unless otherwise indicated, and curtain type stainless steel interlocking blades, with electric motor equipped with instant closure clutch, stainless steel cable damper blade linkage, motor mounting bracket, and 32" long wire leads and with the following construction feature:

1. Unit Assembly: Motor mounted outside air stream.

D. Acceptable Manufacturers:

1. Air Balance, Inc.
2. American Warming & Ventilating, Inc.
3. Arrow Louver and Damper; Div. of Arrow United Industries Inc.
4. Louvers and Dampers, Inc.
5. Penn Ventilator Co.
6. Phillips-Aire

2.20 TURNING VANES

A. Fabricated Turning Vanes: Provide fabricated turning vanes and vane runners, constructed in accordance with SMACNA "HVAC Duct Construction Standards".

B. Manufactured Turning Vanes: Provide turning vanes constructed of 1¼" wide curved blades set at 3/4" o.c., supported with bars
perpendicular to blades set at 2" o.c., and set into side strips suitable for mounting in ductwork.

C. Acoustic Turning Vanes: Provide acoustic turning vanes constructed off airfoil shaped aluminum extrusions with perforated faces and fiberglass fill.

D. Acceptable Manufacturer: Subject to compliance with requirements, provide turning vanes of one of the following:
   1. Aero Dyne Co.
   2. Airsan Corp.
   3. Anemostat Products Div.; Dynamics Corp. of America
   4. Barber-Colman Co.
   5. Duro Dyne Corp.
   8. Register & Grille Mfg. Co., Inc.
   9. Souther, Inc.

2.21 DUCT HARDWARE

A. General: Provide hardware, manufactured by one manufacturer for all items on project, for the following:
   1. Test Holes: Provide in ductwork at fan inlet and outlet, and elsewhere as indicated, duct test holes, consisting of slot and cover, for instrument test.

   2. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.

B. Acceptable Manufacturers:
   1. Ventfabrics, Inc.
   2. Young Regulator Co.

2.22 DUCT ACCESS DOORS

A. Construction: Construct of same or heavier gauge as ductwork served, provide insulated doors for insulated ductwork. Provide flush frames for uninsulated ductwork, extended frames for externally insulated duct. Provide one size hinged, other side
with one handle-type latch for doors 12" high and smaller, 2 handle-type latches for larger doors.

B. Acceptable Manufacturers:

1. Air Balance Inc.
2. Duro Dyne Corp.
3. Register & Grille Mfg. Co., Inc.
5. Ventfabrics, Inc.

2.23 FLEXIBLE CONNECTIONS

A. General: Provide flexible duct connections wherever ductwork connects to vibration isolated equipment. Construct flexible connections of neoprene-coated flameproof fabric crimped into duct flanges for attachment to duct and equipment. Make airtight joint. Provide adequate joint flexibility to allow for thermal, axial, transverse, and torsional movement, and also capable of absorbing vibrations of connected equipment.

B. Acceptable Manufacturers:

2. Duro Dyne Corp.
3. Flexaust (The) Co.
4. Ventfabrics, Inc.

PART 3 - EXECUTION

3.1 GENERAL

A. Examine areas and conditions under which ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Assemble and install ductwork which will achieve air-tight (5% leakage for systems rated 2 inches static pressure and under; 1% for systems rated over 2 inches static pressure) systems with no objectionable duct generated noise. Install each run with minimum number of joints. Align ductwork accurately at connections, within 1/8" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type which will hold ducts true-to-shape and to prevent
buckling. Support vertical ducts at every floor, and at a maximum of 15 feet intervals between floors.

C. Install additional bracing or supports to eliminate any distortion or vibration when the systems are operating or under tests.

D. Install ducts, casings and hangers plumb and level, with joints square and devoid of sharp edges.

3.2 DUCTS

A. Route ductwork to minimize directional changes and prevent abrupt transitions.

B. Provide adequate space around ducts to assure proper support and to allow the installation of the insulation specified.

C. Provide fairings where pipes or structures must penetrate ducts. When fairing is longer than two feet maintain the original velocity. When fairing is shorter than two feet the velocity may be increased by not more than 10 percent.

D. Install instrument test holes in the duct or casing on the up and downstream side of each coil and the downstream side of each fan and where pitot tube readings are indicated on the drawings or are required for air balance.

E. Install turning vanes in elbows whose center line radius is less than 150 percent of the duct width and where indicated on the Drawings.

F. Where hanger rods for ducts, piping or equipment must pierce ducts, provide closure plates fitted around the rod and riveted or welded to the duct. Use in conjunction with GE Sil-Proof sealant to make an airtight seal.

G. Make all connections between ductwork, including flexible connections, fittings and equipment with gradually tapered transition fittings.

H. Where ductwork size does not conform to nearest standard automatic damper size, transform duct to match damper.

I. Provide 14 ga. galvanized steel sleeves in floor slabs where ducts pass through except where the ducts are in masonry enclosed shafts. Sleeve shall project 3 in. above and below the floor slab or curb. Duct shall be connected directly to the sleeve. Where fire dampers are installed, connect duct as per manufacturers instruction and in accordance with applicable codes.

J. Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.
K. Locate ductwork rungs, except as otherwise indicated, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls overhead construction, columns, and other structural and permanent enclosure elements of building. Limit clearance to 1/2" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible locating in mechanical shafts, hollow wall construction above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

L. Do not route ductwork through transformer vaults and their electrical equipment spaces and enclosures.

M. Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on 4 sides at least 1.5". Fasten to duct and substrate.

N. Where ducts pass through fire-rated floors, walls, or partitions, provide firestopping around duct, in accordance with requirements of Division 7 Section "Firestopping".

O. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

3.3 INSTALLATION OF DUCT LINER

A. Install duct liner in accordance with SMACNA HVAC Duct Construction standards.

3.4 INSTALLATION OF FLEXIBLE DUCTS

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 6' - 0" extended length.

B. Installation: Install in accordance with Section III of SMACNA's, "HVAC Duct Construction Standards, Metal and Flexible".

3.5 INSTALLATION OF DUCTWORK ACCESSORIES

A. Install ductwork accessories in accordance with manufacturer's installation instructions to ensure that products serve intended function.
B. Install turning vanes in square or rectangular 90 deg elbows in supply return and exhaust air systems, and elsewhere as indicated.

C. Install access doors to open against system air pressure, with latches operable from either side.

D. Coordinate with other work, including ductwork, as necessary to interface installation of ductwork accessories properly with other work.

3.6 CASINGS

A. Unless specifically shown differently on the Drawings or where required for clearance, construct all casings with constant cross-section. Arrange air treatment equipment within casings to give the most direct air flow to the center line of the fan. Provide sheet metal filler pieces to prevent air bypass. Where constant cross-section casings cannot be used, maximum transitional slope for top and sides of casings shall be 30 degrees.

B. Mount fans so that the center line of the fan inlet is on the center line of the air treatment equipment. Maximum transition slope to the fan inlet shall be 40 deg.

3.7 DRAIN PANS AND TROUGHS

A. Provide drain pans for all duct mounted cooling coils and casings.

3.8 FIELD QUALITY CONTROL

A. Leakage Tests: After each duct system which is constructed for duct classes over 2" is completed, test for duct leakage in accordance with SMACNA HVAC Air Duct Leakage Test Manual. Repair leaks and repeat tests until total leakage is less than 1% of system design air flow.

B. Operate installed ductwork accessories to demonstrate compliance with requirements. Test for air leakage while system is operating. Repair or replace faulty accessories, as required to obtain proper operation and leakproof performance.

3.9 EQUIPMENT CONNECTIONS

A. General: Connect ductwork to equipment as indicated, provide flexible connection for each ductwork connection to equipment mounted on vibration isolators, and/or equipment containing rotating machinery.

3.10 ADJUSTING AND CLEANING

A. Clean ductwork internally, unit by unit as it is installed, of dust and debris. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where
ductwork is to be painted, might interfere with painting or cause paint deterioration.

B. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.

C. Temporary Closure: At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

D. Adjusting: Adjust ductwork accessories for proper settings, install fusible links in fire dampers and adjust for proper action.

END OF SECTION
SECTION 23 31 03
AIR DISTRIBUTION LOW PRESSURE AND HIGH PRESSURE DUCTWORK

1.0 GENERAL

1.1 Furnish and install all sheet metal work including ductwork and connections to fans and equipment. Sheet metal ducts shall be provided and installed as shown on the drawings. All details of the ductwork are not indicated and the necessary bends, off-sets and transformations must be furnished whether shown or not.

2.0 MATERIAL USED

2.1 Sheet metal ductwork shall be made of one of the following materials:

a. Primer quality (lock forming quality) zinc coated steel sheets.

b. Aluminum sheets No. 3003-H 14, 3S-1/2 hard.

c. Each sheet of metal used in construction of ductwork shall be factory labeled with the trade name and gauge of the sheet.

3.0 CONSTRUCTION

3.1 The recommended construction method of bracing and reinforcing and types of joints and seams are shown in the following tabulations:

a. Rectangular low pressure ductwork (-2.0 to +2.0 IWG)

<table>
<thead>
<tr>
<th>Aluminum B&amp;S Gage</th>
<th>Steel US Std. Gage</th>
<th>Maximum Side Ins.</th>
<th>Type of Transverse Joint Connections</th>
<th>Bracing</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>26</td>
<td>Up to 12</td>
<td>S. drive, pocket or bar slips on 7'10&quot;</td>
<td>None</td>
</tr>
<tr>
<td>22</td>
<td>24</td>
<td>13 to 24</td>
<td>S. drive, 1&quot; pocket 1&quot; bar slips on 4'0&quot; centers</td>
<td>None</td>
</tr>
<tr>
<td>20</td>
<td>22</td>
<td>25 to 30</td>
<td>S. drive, 1&quot; pocket 1&quot; bar slips on 4'0&quot; centers</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41 to 60</td>
<td>1½&quot; angle connections or 1½&quot; pocket or 1½&quot; bar slips with 1&quot; x 1/8&quot; bar reinforcing on 7'10&quot; centers</td>
<td>1½&quot; x 1½&quot; x 1/8&quot; angles; 4&quot; from joints</td>
</tr>
<tr>
<td>18</td>
<td>20</td>
<td>61 to 90</td>
<td>1½&quot; angle connections or 1½&quot; pocket or 1½&quot; bar slips 4'0&quot; maximum centers with 1&quot; x 1/8&quot; bar reinforcing</td>
<td>1½&quot; x 1½&quot; 1/8&quot; diagonal angles or 1½&quot; x 1½&quot; x 1/8&quot; angles 2' from joint</td>
</tr>
</tbody>
</table>
Notes:

1. All ducts 18" and larger should be cross-broken. Cross breaking may be omitted if ducts of metal two gages heavier is used.

2. Ducts larger than 90 inches require special field study for handling and supporting.

   b. Low Pressure Round Ducts (Dust Collection)

<table>
<thead>
<tr>
<th>Diameter of Duct inches</th>
<th>Aluminum B&amp;S Gage</th>
<th>Steel U.S. Std. Gage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 13</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>13½ to 33½</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>34 to 67½</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

   c. High Pressure Rectangular Ducts (±3.0 IWG and up)

<table>
<thead>
<tr>
<th>Maximum Side inches</th>
<th>Aluminum B&amp;S Gage</th>
<th>Steel U.S. Std. Gage</th>
<th>Joints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 24</td>
<td>20</td>
<td>22</td>
<td>Flange gasketed or butt welded with adequate reinforcement</td>
</tr>
<tr>
<td>25 to 48</td>
<td>18</td>
<td>20</td>
<td>Flange gasketed or butt welded with adequate reinforcement</td>
</tr>
<tr>
<td>49 to 60</td>
<td>16</td>
<td>18</td>
<td>Flange gasketed or butt welded with adequate reinforcement</td>
</tr>
<tr>
<td>61 to up</td>
<td>16</td>
<td>18</td>
<td>Flange gasketed or butt welded with adequate reinforcement</td>
</tr>
</tbody>
</table>

NOTE: All ducts over 18" in either dimension are cross-broken except those with rigid board insulation applied.

4.0 CIRCULAR FLEXIBLE AIR DUCT

4.1 Circular flexible duct shall be highly flexible, making bends without kicking, fabricated with an electro-galvanized cold rolled steel supporting spiral and vinyl coated glass fabric or aluminum bonded to glass fabric. Material shall be similar to "Wiremold" types 57 to 52 specially constructed for air conditioning service, as specified on the drawings.
4.2 Joints between duct sections for high and medium pressure applications shall be made using "Minnesota Mining Co." EC-750 or Tape #691 or equivalent.

4.3 Joints between duct sections and boxes shall be made using EC-750 or EC-800 sealer and specially designed strap clamps.

5.0 ELBOWS AND TRANSFORMATIONS

5.1 Elbows

a. No turns shall be made with an inside radius of less than the width of the duct unless otherwise shown or required by unavoidable space conditions. Should any turns be necessary with an inside radius less than 3/4 depth of the duct, they must be fitted with double thickness multiple vanes.

5.2 Transformations

a. Transformations in duct shape or dimensions shall be made with gradual slopes on all sides. Duct expansions in the air flow direction shall have maximum slope of 1" in 7" on any side. Duct contraction in the air flow direction should be made with slope of 1" in 87" on any side but maximum slope of 1" may be permitted when so demanded by space limitations.

6.0 HANGER

6.1 All horizontal ductwork shall be supported on hangers at not more than 8'0" centers.

6.2 For ducts with a long dimension less than 36 inches, hangers shall be 1 inch wide strips of 16 gauge galvanized steel.

6.3 For ducts with long dimension between 37 to 60 inches hangers shall be 1 inch by 1/8 inch galvanized band iron.

6.4 For ducts larger than 60 inches, hangers shall be trapezes consisting of an angle iron crossmember supported by 3/8" steel rods.

6.5 All hangers shall be securely attached to the ducts with sheet metal screws and to the walls or slabs by means of inserts, toggle bolts, or other approved means. Hangers for insulated ducts shall be installed on the exterior of the insulation so as not to puncture insulation vapor seal.

7.0 VERTICAL DUCTS PASSING

7.1 Vertical ducts passing from one floor to the next shall be supported at the floor slab on angle irons securely attached to the ducts and resting on the floor. For ducts with the
larger dimensions not exceeding 60 inches use angle irons 1" x 1/8" and for larger ducts, 1¼" x 1½" x 1/8" angle irons shall be used.

8.0 DUCTS PENETRATIONS

8.1 Ducts shall be run so as to avoid interferences with pipes, conduits or ceiling hangers. However, where duct penetration are unavoidable, streamline-shaped sleeves around such lines or hangers shall be provided to facilitate air flow. If such sleeves obstruct duct cross section in more than 20 percent, the duct shall be transformed so as to maintain the necessary area.

9.0 PLENUMS

9.1 Plenums, coil casings, mixing chambers, etc., shown on the drawings shall be constructed as specified and with adequate reinforcement.

9.2 All plenums, casings, mixing chambers, etc., shall be provided with access doors shown of sufficient size to permit easy access and servicing of equipment enclosed. Door shall be tight fitting, gasketed and with friction latches. They shall be insulated to the same thickness as the level surface on which they are mounted and the insulation shall be metal-clad to protect it from physical damage.

10.0 DUCT PAINTING

10.1 Duct collars behind grilles, registers and ceiling outlets shall be painted inside with two coats of flat black paint.

10.2 Duct hangers shall be thoroughly wire-brushed clean and given one coat of red lead primer and one coat of machinery gray lead and brushed clean, apply one coat of RPM Metallic Coating as manufactured by Republic Powdered Metals of similar.

10.3 All exposed to view uninsulated ducts and sheet metal housings shall be given a prime coat and finish painted with two coats of enamel of the color selected by the Architect.

11.0 WORKMANSHIP

11.1 All ductwork shall be free from rattles and air noises when in operation. Duct work shall present a smooth interior and joints must be tight and shall be caulked or soldered if necessary to accomplish this object.
12.0 DAMPERS AND SPLITTERS

12.1 Dampers and splitters shall be installed as required to afford complete control of the air flow in the various duct systems.

12.2 Splitter dampers shall be constructed of #20 gage galvanized steel riveted or welded to square operating rods. The length of any splitter blade shall be 1½ times the width of the split in the duct, but shall not less than 12 inches.

12.3 Butterfly-type volume dampers shall also be made of #20 gage galvanized steel and only shall be used if neither dimension of the damper exceeds 18 inches. When either multi-louver type dampers shall be used.

12.4 Multi-louver dampers shall be constructed of 16 gage either galvanized or with a baked enamel finish. Blades shall be mounted in suitable hand or angle from frame with enough rigidity.

12.5 Blades, all linked together to be controlled from a single point shall not be more than 11 inches in width and shall be for opposed action, felted when tight closure is mandatory. Damper bearing shall be brass or bronze sleeve bearings.

12.6 Access registers shall be provided in the ductwork to service bearings on louver-type dampers. Also appropriate registers shall be provided to service the fusible link and damper reset of all fire dampers.

12.7 The Contractor shall be responsible for proper marking all places where dampers and splitters are located so other trades can properly locate access panels in the suspended ceiling, when required.

13.0 FIRE DAMPERS

13.1 Where called for on the drawings or where required weighted fire dampers shall be used. The bronze bearing fire dampers shall be held open by fusible links and be constructed following recommendations of the "National Board of Fire Underwriters."

14.0 FLEXIBLE CONNECTIONS

14.1 Flexible connections shall be provided between all air conditioning or exhaust fans and air handling units and the ducts with which they are connected. Connections shall span between 4 to 6 inches and shall be installed with approximately one inch of slack.
14.2 The flexible material shall be fire-resistant, waterproof, 14 ounce canvas similar to "Ventfab" as manufactured by "Ventfabrics Inc." Cotton duck of not less than 15 ounces per square yard shall be permitted when fire hazard is highly improbable.

14.3 All necessary angle irons, bolts, screws, clips or other fastening devices to secure the flexible material to the equipment and ducts shall be supplied.

15.0 ACOUSTICAL DUCT LINER

15.1 Acoustical lining to prevent transmission of noise to the conditioned places shall be attached to the ductwork when shown on the drawings, or if noise levels is objectionable.

15.2 The duct liner shall be non-combustible, odorless, verminproof and coated on own side. Thickness shall not be less than 1/2" and the material shall be designed for the application.

15.3 Liner shall be applied following the manufacturer's recommendations, using "Minnesota Mining Co." EC-104 adhesive to completely coat the adjoining surfaces of sheet metal and liner.

15.4 The Contractor shall submit for approval the manufacturer's name, type, and model or number of the adhesive, clips and any other accessory he proposes to install the acoustic duct liner.

16.0 DUCT THERMAL INSULATION

16.1 All supply and return ducts shall be externally thermal insulated with a minimum of 1" thick 1½ pounds density fiber glass blanket or as called for in the drawings.

16.2 Blanket or flexible type of duct insulation shall be adhered to the ducts with a fire, retardant adhesive and wired on 12" centers with copper wire, fiber or other cover protecting clips. All joints, either longitudinal or transverse shall be sealed with an approved mastic or adhesive tape.

16.3 Rigid board insulation shall be applied using the proper type and amount of clips which shall be adhered to the duct with a fire retardant adhesive. Special care shall be taken to thoroughly seat all joints with adequate sealer mastic or tape.

16.4 No sheet metal screws entering into the duct shall be permitted to be fastened to the insulation of the sheet metal.
16.5 Provide an 8 ounce canvas jacket protective covering over insulation exposed in machine room, in air unit rooms, or where additionally shown on the drawings.

16.6 When cement plaster is specified as finish for exposed ductwork, the Contractor shall furnish the 3.5 lb. galvanized wire mesh to receive the plaster.

16.7 The Contractor shall submit for approval the manufacturer's name, type and model or number of the adhesive, clips, sealer mastic and tape that intend to use in connection with the thermal insulation of ductwork.

16.8 Blanket of flexible type of duct insulation shall be faced with a layer of aluminum foil, reinforced with fiberglass yarn mesh and laminated to 40-lb fire resistant KRAFT. This jacket shall be similar to Johns Manville Type FSK and shall have a composite product flame spread rating of 25.

17.0 TESTING

17.1 Low Pressure Systems

a. For systems up to 1 inch of water of total static pressure in the ducts the total leakage will be less than 10 percent of the capacity.

b. The system capacity is defined as the total CFM shown in the drawings. The system capacity shall be determined by adding the CFM to be handled by each supply outlet as shown in the drawings.

c. The leakage shall be determined by the testing procedure described in the Duct Manual for Ventilating and Air Conditioning system High Velocity System, latest edition of the Sheet Metal and Air Conditioning Contractors National Association, Inc.

17.2 Medium and High Pressure Systems

a. For systems from 2 inches to 10 inches of water of total static pressure in the ducts, the total leakage shall be less than 1 percent of the system capacity.

b. System capacity is defined as in 17.1b above. The testing procedure shall be the same as in 17.1c above.

END OF SECTION
SECTION 23 31 06

AIR DISTRIBUTION LOW VELOCITY AND HIGH VELOCITY DUCTWORK

1.0 GENERAL

A. Furnish and install all sheet metal work including ductwork and connections to fans and equipment. Sheet metal ducts shall be provided and installed as shown on the drawings. All details of the ductwork are not indicated and the necessary bends, off-sets and transformations must be furnished whether shown or not.

2.0 MATERIALS USED

A. Sheet metal ductwork shall be made of one of the following materials:

1. Prime quality (lock forming quality) zinc coated steel sheers.

2. Aluminum sheets No. 3003-H-14, 3S-1/2 hard.

3. Each sheet of metal used in construction of ductwork shall be factory labeled with the trade name and gauge of the sheet.

3.0 CONSTRUCTION

A. The recommended construction method of bracing and reinforcing and types of joints and seams are shown in the latest edition of SMACNA Low Velocity and High Velocity Duct Construction Standards.

4.0 CIRCULAR FLEXIBLE AIR DUCT

A. Circular flexible duct shall be highly flexible, making bends without kinking, fabricated with an electro-galvanized cold rolled steel supporting spiral and vinyl coated glass fabric or aluminum bonded to glass fabric. Material shall be similar to “Wiremold” types 57 to 52 specially constructed for air conditioning service, as specified on the drawings.

B. Joints between duct sections for high and medium pressure applications shall be made using “Minnesota Mining Co.” EC-750 or Tape #691 or equivalent.

C. Joints between duct sections and boxes shall be made using EC-750 or EC-800 sealer and specially designed strap clamps.
5.0 ELBOWS AND TRANSFORMATIONS

A. Elbows

1. No turns shall be made with an inside radius of less than the width of the duct unless otherwise shown or required by unavoidable space conditions. Should any turns be necessary with an inside radius less than 3/4 depth of the duct, they must be fitted with double thickness multiple vanes.

2. Square elbows shown or required shall be provided with double thickness vanes similar to Ducturns or Tuttle and Bailey of Barber Colman Airturns. Job fabricated vanes will only be acceptable on approval of detailed drawings showing the method of fabrication spacing of vanes, and gauges of metal.

B. Transformations:

1. Transformations in duct shape or dimensions shall be made with gradual slopes on all sides. Duct expansions in the airflow direction shall have maximum slope in 1” in 7” on any side. Duct contraction in the airflow direction should be made with slope of 1” in 87” on any side but maximum slope of 1” may be permitted when so demanded by space limitations.

6.0 HANGERS

A. All horizontal ductwork shall be supported on hangers at not more than 8’0” centers.

B. For ducts with a long dimension less than 36 inches, hangers shall be one-inch wide strips of 16 gauge galvanized steel.

C. For ducts with long dimension between 37 to 60 inches hangers shall be 1 by 1/8-inch galvanized band iron.

D. For ducts larger than 60 inches, hangers be trapezes consisting of an angle cross-member supported by 3/8” steel rods.

E. All hangers shall be securely attached to the ducts with sheet metal screws and to the walls or slabs by means of inserts, toggle bolts, or other approved means. Hangers for insulated ducts shall be installed on the exterior of the insulation so as not to puncture insulation vapor seal.

7.0 VERTICAL DUCTS PASSING

A. Vertical ducts passing from one floor to the next shall be supported at the floor slab on angle irons securely attached to the ducts and resting on the floor. For ducts with the larger dimensions not exceeding 60 inches use angle irons 1”
x 1/8", and for larger ducts 1⅛" x 1⅛" x 1/8" angle irons shall be used.

8.0 DUCTS PENETRATIONS

A. Ducts shall be run so as to avoid interferences with pipes, conduits or ceiling hangers. However, where duct penetrations are unavoidable, streamline shaped sleeves around such lines or hangers shall be provided to facilitate airflow. If such sleeves obstruct duct cross section in more than 20 percent, the duct shall be transformed so as to maintain the necessary area.

9.0 PLENUMS

A. Plenums, Coil shown on the specified and casings, mixing chambers, etc. drawings shall be constructed with adequate reinforcement.

B. All plenums, casings, mixing chambers, etc., shall be provided with access doors shown of sufficient size to permit easy access and servicing of equipment enclosed. Doors shall be tight fitting, gasketed and with friction latches. They shall be insulated to the same thickness as the level surface on which they are mounted and the insulation shall be metal-clad to protect it from physical damage.

10.0 DUCT PAINTING

A. Duct collars behind grilles, registers and ceiling outlets shall be painted inside with two coats of flat back paint.

11.0 WORKMANSHIP

A. Duct hangers shall be thoroughly wire-brushed clean and given one coat of red lead primer and one coat of machinery gray lead and brushed clean, apply one coat of RPM Metallic Coating as manufactured by Republic Powdered Metals or similar.

B. All exposed to view uninsulated ducts and sheet metal housings shall be given a prime coat and finish painted with two coats of enamel of the color selected by the Architect.

C. All ductwork shall be free from rattles and air noises when in operation. Ductwork shall present a smooth interior and joints must be tight and shall be caulked or soldered, if necessary to accomplish this object.

12.0 DAMPERS AND SPLITTERS

A. Dampers and splitters shall be installed as required to afford complete control of the airflow in the various duct systems.
B. Splitter dampers shall be constructed of #20 gage galvanized steel riveted or welded to square operating rods. The length of any splitter blade shall be 1½ times the width of the split in the duct, but shall be not less than 12 inches.

C. Butterfly-type volume dampers shall also be made of #20 gage galvanized steel and only shall be used if neither dimension of the damper exceeds 18 inches. When either dimension exceeds 18 inches multi-louver type dampers shall be used.

D. Multi-louver dampers shall be constructed of 16 gage either galvanized or with a baked enamel finish. Blades shall be mounted in suitable hand or angle from frame with enough rigidity.

E. Blades, all linked together to be controlled from a single point shall not be more than 11 inches in width and shall be for opposed action, felted when tight closure is mandatory. Damper bearing shall be brass or bronze sleeve bearings.

F. Access registers shall be provided in the ductwork to service bearings on louver-type dampers. Also appropriate registers shall be provided to service the fusible link and damper reset of all fire dampers.

G. The Contractor shall be responsible for proper marking all places where dampers and splitters are located so other trades can properly locate access panels in the suspended ceiling, when required.

13.0 FIRE DAMPERS

A. Where called for on the drawings or where required weighted fire dampers shall be used. The bronze bearing fire dampers shall be held open by fusible links and be constructed following recommendations of the “National Board of Fire Underwriters.”

14.0 FLEXIBLE CONNECTIONS

A. Flexible connections shall be provided between all air conditioning or exhaust fans and air handling units and the ducts with which they are connected. Connections shall span between 4 to 6 inches and shall be installed with approximately one-inch of slack.

B. The flexible material shall be fire-resistant, waterproof, 14 ounce canvas similar to “Tentab” as manufactured by “Ventfabrics Inc.” Cotton duck of not less than 15 ounces per square yard shall be permitted when fire hazard is highly improbable.

C. All necessary angle irons, bolts, screws, clips or other fastening devices to secure the flexible material to the equipment and ducts shall be supplied.
15.0 ACOUSTICAL DUCT LINER

A. Acoustical lining to prevent transmission of noise to the conditioned places shall be attached to the ductwork when shown on the drawings, or if noise levels is objectionable.

B. The duct liner shall be non-combustible, odorless, verminproof and coated on own side. Thickness shall not be less than 1/2" and the material shall be designed for the application.

C. Liner shall be applied following the manufacturer’s recommendations, using “Minnesota Mining Co.” EC-104 adhesive to completely coat the adjoining surfaces of sheet metal and liner.

D. The size of ducts indicated on the plans are actual internal sizes and they shall be increased in both dimensions to accommodate the duct liner.

E. The Contractor shall submit for approval the manufacturer's name, type, and model or number of the adhesive, clips and any other accessory he proposes to install the acoustic duct liner.

16.0 DUCT THERMAL INSULATION

A. All supply and return ducts shall be externally thermal insulated with a minimum of 1-inch thick 1 1/2 pounds density fiberglass blanket or as called for in the drawings.

B. Blanket or flexible type of duct insulation shall be adhered to the ducts with a fire, retardant adhesive and wired on 12-inch centers with copper wire, fiber or other cover protecting Clips. All joints, either longitudinal or transverse shall be sealed with an approved mastic or adhesive tape.

C. Rigid board insulation shall be applied using the proper type and amount of clips which shall be adhered to the duct with a fire retardant adhesive. Special care shall be taken to thoroughly seat all joints with adequate sealer mastic or tape.

D. No sheet metal screws entering into the duct shall be permitted to be fastened to the insulation of the sheet metal.

E. Provide an 8 ounce canvas jacket protective covering over insulation exposed in machine room, in air unit rooms, or where additionally shown on the drawings.

F. When cement plaster is specified as finish or exposed ductwork, the Contractor shall furnish the 3.5 lb. galvanized wire mesh to receive the plaster.
G. The Contractor shall submit for approval the manufacturer's name, type and model or number of the adhesive, clips, sealer mastic and tape that intend to use in connection with the thermal insulation of ductwork.

H. Blanket of flexible type of duct insulation shall be faced with a layer of aluminum foil, reinforced with fiberglass yarn mesh and laminated to 40-lb. fire resistant KRAFT. This jacket shall be similar to Johns Manville Type FSK and shall have a composite product flame spread rating of 25.

17.0 TESTING

A. Low Pressure Systems

1. For systems up to 2 inches of water of total static pressure in the ducts the total leakage will be less than 10 percent of the capacity.

2. The system capacity is defined as the total CFM shown in the drawings. The system capacity shall be determined by adding the CFM to be handled by each supply outlet as shown in the drawings.

3. The leakage shall be determined by the testing procedure described in the Duct Manual for Ventilating and Air Conditioning System High Velocity System, latest edition of the Sheet metal and Air Conditioning Contractors National Association, Inc.

B. Medium and High Pressure Systems

1. For systems from 2 to 10 inches of water of total static pressure in the ducts, the total leakage shall be less than one percent of the system capacity.

2. System capacity is defined as in 17.0A. above. The testing procedure shall be the same as in 17.0A. above.

END OF SECTION
SECTION 23 34 00

FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Centrifugal fans.
B. Ceiling fans.
C. Inline ceiling fans.
D. Centrifugal square inline fans.

1.2 RELATED SECTIONS

A. Section 13 05 42 – Seismic Control and Vibration Isolation.

1.3 REFERENCES

B. AMCA 204 - Balance Quality and Vibration Levels for Fans.
C. AMCA 210 - Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
D. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
E. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
F. NEMA MG 1 - Motors and Generators.
G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
H. UL 705 - Power Ventilators.

1.4 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Submittal procedures.
B. Shop Drawings: Indicate size and configuration of fan assembly, mountings, weights, ductwork and accessory connections.
C. Product Data: Submit data on each type of fan and include accessories, fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, electrical characteristics and connection requirements.
D. Manufacturer’s Installation Instructions: Submit fan manufacturer’s instructions.
E. Manufacturer’s Certificate: Certify products meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.

C. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.

D. Balance Quality: Conform to AMCA 204.

E. Energy Recovery Unit Wheel Energy Transfer Rating: Meet ARI 1060.

F. Perform Work in accordance with local and State codes.

1.6 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing Work of this section with minimum three years documented experience.

1.7 PRE-INSTALLATION MEETINGS

A. Section 01 30 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Section 01 60 00 - Product Requirements: Product storage and handling requirements.

B. Protect motors, shafts, and bearings from weather and construction dust.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.10 WARRANTY

A. Section 01 70 00 - Execution Requirements: Product warranties and product bonds.

B. Furnish five year manufacturer’s warranty for fans.
1.11 EXTRA MATERIALS

A. Section 01 70 00 - Execution Requirements: Spare parts and maintenance products.

B. Furnish two sets of belts for each fan.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

A. Manufacturers:

1. Acme Engineering and Manufacturing Corp.
2. Greenheck Corp.
3. Loren Cook Company.
4. Penn Ventilation.

B. Furnish materials in accordance with local and state codes.

C. Wheel and Inlet:

1. Backward Inclined: Steel or aluminum construction with smooth curved inlet flange, back plate, backward curved blades welded or riveted to flange and back plate; cast iron hub riveted to back plate and keyed to shaft with set screws.

2. Forward Curved: Galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to back plate and keyed to shaft with set screw.

3. Airfoil Wheel: Steel construction with smooth curved inlet flange, back plate die formed hollow airfoil shaped blades continuously welded at tip flange, and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.

D. Housing:

1. Steel, spot welded for AMCA 99 Class I and II fans, and continuously welded for Class III, braced, designed to minimize turbulence with spun inlet bell and shaped cut-off.

2. Fabricate plug fans without volute housing, in lined steel cabinet.

E. Bearings and Sleeves:

1. Bearings: Pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA 9 L-10 life at 50,000 hours.
2. Shafts: Hot rolled steel, ground and polished, with key way, protectively coated with lubricating oil, and shaft guard.

3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 hp and under, selected so required rpm is obtained with sheaves set at mid-position. Fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of motor.

4. Belt Guard: Fabricate to SMACNA Standard; 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

F. Accessories:

1. Fixed Inlet Vanes: Steel construction with fixed cantilevered inlet guide vanes welded to inlet bell.

2. Discharge Dampers: Opposed blade steel damper assembly with blades constructed of two plates formed around and welded to shaft, channel frame, sealed ball bearings, with blades linked out of air stream to single control lever.


4. Access Doors: Shaped to conform to scroll, with quick opening latches and gaskets.

5. Scroll Drain: 1/2 inch steel pipe coupling welded to low point of fan scroll.

2.2 CEILING FANS

A. Manufacturers:

1. Acme Engineering and Manufacturing Corp.

2. Greenheck Corp.

3. Loren Cook Company.

4. Penn Ventilation

B. Centrifugal Fan Unit: Direct driven with galvanized steel housing lined with 1/2 inch acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge opening, integral outlet duct collar. Discharge position convertible by moving interchangeable panels.

C. Disconnect Switch: Fan mounted toggle switch for thermal overload protected motor.
D. Grille: Molded white plastic or aluminum with baked white enamel finish.

E. Wheel: Centrifugal forward curved type constructed of injection molded or polypropylene resin.

F. Motor: Open drip proof type with permanently lubricated sealed bearings and thermal overload protection.

G. Accessories:
   1. Wall cap with damper, round duct inlet.
   2. Wall cap with rectangular duct inlet.
   3. Eave elbow.
   4. Filter box.
   6. Fan speed controller.
   7. Time delay relay.

2.3 INLINE CEILING FANS

A. Manufacturers:
   1. Acme Engineering and Manufacturing Corp.
   2. Greenheck Corp.
   3. Loren Cook Company.
   4. Penn Ventilation.

B. Configuration: Inline.

C. Centrifugal Fan Unit: Direct driven with galvanized steel housing lined with 1/2 inch acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge opening, integral inlet and outlet duct collar.

D. Disconnect Switch: Fan mounted toggle switch for thermal overload protected motor.

E. Wheel: Centrifugal forward curved type constructed of injection molded or polypropylene resin.

F. Motor: Open drip proof type with permanently lubricated sealed bearings and thermal overload protection, mounted on rubber-shear isolators.
PART 3 – EXECUTION

3.1 EXAMINATION

A. Section 01 30 00 – Administrative Requirements: Coordination and project conditions.

3.2 INSTALLATION

A. Suspended Fans: Install flexible connections between fan and ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
B. Install backdraft dampers on inlet to roof and wall exhaust fans.
C. Provide backdraft dampers on outlet from cabinet and ceiling fans and as indicated on Drawings.
D. Install safety screen where inlet or outlet is exposed.
E. Pipe scroll drains to nearest floor drain.
F. Install backdraft dampers on discharge of exhaust fans and as indicated on Drawings.
G. Provide sheaves required for final air balance.

3.3 MANUFACTURER’S FIELD SERVICES

A. Section 01 40 00 – Quality Requirements: Requirements for manufacturer’s field services.
B. Furnish services of factory trained representative for minimum of one days to start-up, calibrate controls, and instruct Owner on operation and maintenance.

3.4 PROTECTION OF FINISHED WORK

A. Section 01 70 00 – Execution Requirements: Requirements for protecting finished Work.
B. Do not operate fans for until ductwork is clean, filters in place, bearings lubricated, and fan has been test run under observation.

END OF SECTION
SECTION 23 37 00

AIR DISTRIBUTION OUTLETS
AND CONTROL DEVICES

PART 1 – GENERAL

1.1 GENERAL

A. Diffusers, registers, grilles and louvers shall be furnished and installed at all supply, return and exhaust openings as indicated on the drawings.

1.2 CEILING DIFFUSERS

A. Ceiling diffusers shall be of standard construction and of the circular, square or rectangular type as specified on the drawings.

B. Diffusers shall be of steel or aluminum construction as specified on the drawings. If steel construction is specified, they shall be furnished with a metalescent aluminum finish.

C. All ceiling diffusers shall be provided with equalizing deflectors or grids to produce air flow perpendicular to the diffuser and with face operated air volume dampers unless otherwise specified on the drawings.

1.3 SUPPLY AIR GRILLES AND REGISTERS

A. Supply air grilles and registers shall be of the four way deflection, adjustable blades type, with front set of blades parallel to the shorter dimensions.

B. Registers shall be furnished with opposed blade front key or level operated air volume control.

C. Grilles and registers shall be furnished in steel construction with a baked metalscent finish or in aluminum construction as specified. When indicated on the plans behind each grille an air extract and volume controller similar to Titus AG-45 shall be furnished.

1.4 RETURN GRILLES AND REGISTERS

A. Return grilles and registers shall be of the fixed fin type with fans set at an angle of 45° and shall have a minimum free area of 75 percent.

B. Registers shall be furnished with opposed blade front key or lever operated air volume control.

C. Grilles and registers shall be furnished in steel construction as specified.
1.5 EXHAUST GRILLES AND REGISTERS

A. Exhaust grilles and registers shall be identical to return grilles and registers as described in preceding paragraph.

1.6 DOOR GRILLES

A. Metallic door grilles shall be furnished by the Contractor and turned over to the General Contractor for installation in the doors.

B. Grilles shall be of the sight-tight model with V-shaped fixed fins and with a minimum of 75 percent free area, with an auxiliary adjustable frame to fit varying door thickness giving installation finished appearance for both sides of the door or partition.

C. Grilles shall be of steel with a baked metal-salient aluminum finish.

1.7 OUTSIDE AIR INTAKES

A. Fresh air louvers shall be of fixed leak-proof aluminum construction with not less than 50 percent free area. Frame and louver blades shall be fabricated from not less than #12 gage aluminum sheet.

B. Louvers shall be provided with a 1/4" x 1/4" mesh aluminum wire bird screen so situated to permit easy access for cleaning.

C. Each fresh air intake shall be provided with a blade volume control damper for either manual or motorized operation as shown on the drawings.

1.8 PLASTER FRAMES

A. Unless otherwise indicated or specified where grilles and registers are set in mortar or masonry, special plaster frames with felt or rubber gaskets shall be used.

1.9 SIZES, TYPES AND CONSTRUCTION OF CEILING AND WALL OUTLETS

A. The sizes, types and construction of all ceiling diffusers, sidewall, grilles, returns, exhaust, door grilles and outside air intakes are indicated on the drawings.

1.10 CONTROL DEVICES

A. Unless otherwise stated on the drawings the grille accessories shall be as follows:

1. Where a grille runout does not exceed two feet in length and the face of the grille is parallel to the side of the supply
duct into which the runout is tapped shall be used for the dual purpose of air distribution and volume control.

2. Where a grille runout exceeds two feet in length and or the face of the grille is parallel to the side of the supply duct into which the runout is lapped, the runout shall be considered a branch duct provided with a splitter damper; and a device to insure an absolute even distribution of air over the entire supply grille or register shall be used.

3. Where a ceiling outlet runout does not exceed two feet in length and the face of the ceiling outlet is parallel to the side of the supply duct into which the runout is tapped, a deflectrol or approved equal device shall be installed in the throat of the outlet. The deflectrol and the volume control damper may be combined in a single device.

4. When the ceiling outlet runout exceeds two feet in length, it shall be considered a branch duct and shall be provided with a splitter damper. Where the air in such a branch approaches perpendicular to the face of the outlet latter shall be fitted with the distribution device which is standard with the ceiling outlet manufacturer. Where air approaches parallel to the face of the outlet, a deflectrol or approved equal device shall be installed to direct the air into the collar of the outlet.

5. Each splitter or volume damper, unless specified for automatic operation shall be fitted with an adjusting device having a looking mechanism. The adjusting devices shall be similar to the following types of Young Regulator Company operators.

a. For all volume dampers and for splitter dampers of less than 19" length, types No. 1, No. 301, or No. 315.

b. For splitter dampers of 19" or greater length type No. 900 shall be used.

c. For both volume and splitter dampers which are so located that the adjusting devices would otherwise be inaccessible types No. 912 or 914 shall be used.

1.11 CONTROL DEVICES

A. On exposed ductwork the adjusting devices shall be fastened to the duct. Where the ductwork is concealed by non-removable furring, the adjusting devices shall be fastened to the furring and exposed in the finished space. On insulated exposed ducts the adjusting devices shall be fastened to wooden blocks inset into the insulation and vapor sealed.
SECTION 23 70 29
CUSTOM BUILT AIR HANDLING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. This specification covers the basic parameters for furnishing and delivering air handling units to Puerto Rico.

B. All equipment shall be delivered to the job site export packaged and protected for overseas shipping and for storing the equipment outside exposed to the weather.

C. Where multiple units are required, a schedule of priority will be furnished which shall determine the manufacturing and delivery sequence.

D. In general, units shall be delivered in one piece. Where size and trucking limitations require that the units be shipped in more than one piece, the manufacturer shall indicate this on the shop drawings.

E. Supplier shall furnish the services of a competent factory trainer representative(s) as described elsewhere in these specifications.

1.2 INTENT AND CODES

A. This specification describes the equipment required. It does not cover all phases of manufacture of assembly. Supplier shall assume the responsibility for providing well-integrated units of good quality.

B. All codes, rules, regulations and ordinances governing this work, are as fully a part of this specification as if herein repeated or hereto attached. Where the requirements of this specification are more stringent than any applicable codes etc., the specification shall apply.

1.3 STANDARDS

A. The latest published issues of the standards, recommendations or requirements of the following listed societies, associations or institutes in effect at the date of contract are part of this specification.

B. These shall be considered as minimum requirements; specific requirements of the specification shall have precedence. In case of conflict between published requirements, Owner's Representative shall determine which is to be followed.

1. AMCA - Air Moving and Conditioning Association

2. ANSI - American National Standards Institute
3. ASA - Acoustical Society of America
4. ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers
5. OSHA - Occupational Safety and Health Act of 1970
6. ASME - American Society of Mechanical Engineers
7. AISC - American Institute of Steel Construction
8. PRBC#7 - Puerto Rico Building Code-Planning Regulation No. 7 and Supplements
9. FM - Factory Mutual Standards
10. ASTM - American Society of Testing Materials
11. NBFU - National Board of Fire Underwriters
12. NFPA - National Fire Protection Association
13. UL - Underwriters' Laboratory of National Board of Fire Underwriters
14. NEMA - National Electric Manufacturers Associations
15. NEC - National Electric Code
16. ARI - Air Conditioning and Refrigeration Institute
17. SMACNA - Sheet Metal and Air Conditioning Contractors National Association

1.4 MATERIALS AND WORKMANSHIP

A. Unless otherwise specified all materials shall be new. Supplier shall be responsible for defects in equipment and devices furnished but not manufactured by him. Exposed finishes and other features shall match in all respects. Supplier alone shall be responsible for all errors of fabrication and for correct fitting of all components that must be erected and joined in the field.

1.5 PROPOSAL

A. The proposal shall provide a total cost and individual unit costs. Any exceptions to, or deviations from this specification, which the manufacturer must make to permit him to bid, shall in proposal, be fully itemized and explained in sufficient detail to permit evaluation. Failure by the manufacturer to furnish the necessary information may disqualify his proposal from consideration.

B. To receive consideration, the proposal shall include the technical information as outlined by the Appendixes I and II data sheets. A
data sheet must be filled for each unit and coil. Performance data of the various components is given on drawings.

C. The proposal shall include an outline sketch showing the overall dimensions and placement of component equipment.

D. The supplier shall include in his proposal, their per diem charge for the services of a factory representative who shall be qualified to inspect, advise and supervise all phases of the installation and any other related work involved in the installation as may be necessary to check, test, start and adjust the equipment. He shall also be competent to instruct the Owner's operating personnel in the proper operation and care of the equipment. Such factory representative(s) need not be resident on the job site but shall be available on call.

1. Services in conjunction with the equipment installation, placement in service and instruction for operating personnel are included in the bid price.

2. Services requested in writing by the Owner's Representative are chargeable at the per diem rate. Per diem charges for technical services, for an eight hour day, includes all wages, allowance, living expenses, transportation from the supplier's place of business to the job site and return including local transportation.

1.6 INFORMATION TO BE SUBMITTED WITH BID

A. The manufacturer shall include with his proposal the following information:

1. Base lump sum price and breakdown as per paragraph 1.05.

2. Complete capacity and performance and testing data including all items indicated on the schedules.

3. In addition to other data regarding fan construction and performance, submit to the engineers for approval complete certified data for each fan with additional copies for inclusion in the Instruction Manual as follows:

   a. Curves showing at the fan speed indicated in the schedule, the relationship between the air handled by the fan from zero to the maximum obtainable in cfm and the following:

      1) Air Quantity Delivered (CFM)
      2) Total Static Pressure (TSP)
      3) Brake Horsepower (BHP)
      4) Speed of Fan Wheel (RPM)
      5) Number of Blades on Fan Wheel
6) Fan Wheel Diameter
7) Peak Static Efficiency
8) Actual Static Efficiency
9) Equipment Weight

4. Data relating to sound level produced at the fan outlet when operating at design conditions in accordance with AMCA Bulletin 300, Recommended Practice for Sound Testing of Air Moving Devices.

5. Dimensioned drawings indicating weight distribution and location and size of all pipe, duct and electrical connections.

6. Complete electrical interconnection, ladder, and schematic diagram clearly indicating all factory and field wiring distinctly.

1.7 INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTION

A. The successful vendor shall deliver to the Owner within 60 days of contract award, one hard bound copy and one CD with an electronic copy of the installation, operating and maintenance data of all equipment furnished. The Manuals shall include:

1. Model and Serial No's. of all equipment.
2. Performance data.
3. Manufacturer's written instructions for the installation, operation and maintenance of the component equipment.
4. Lubrication schedule indicating all equipment to be lubricated, recommended lubrication interval and type and quality of lubricant to be used.
5. Recommended spare parts list for each one of the components. List shall have unit prices.

1.8 INSPECTION AND SHOP TESTS

A. Materials and/or equipment covered by this specification shall be subject to inspection by the Owner. Owner's Representative shall, during working hours, have access to all parts of the shop where material to be used in this equipment is being manufactured and shall be provided with all reasonable inspection facilities. Release of material and/or equipment shall not relieve the supplier from contract responsibilities nor invalidate any claim which the Owner may make because of unsatisfactory materials and/or construction.
B. Operational tests required by the Owner's Representative during inspection to demonstrate that equipment and components comply with the specification shall be made by the supplier. Tests shall be made with all removable elements in place unless otherwise permitted by the Owner's Representative.

1.9 SHIPPING PROTECTION AND INSPECTION

A. All material, equipment and component parts shall be adequately protected to prevent damage, corrosion or entry of foreign matter during shipment, unheated storage and a dusty atmosphere.

B. Each packing crate and carton containing components shall be visibly stenciled, clearly identifying contents as to the type(s) of unit(s) contained herein and the related equipment assembly or assemblies.

C. Each shipment shall contain packing slip listing all components.

D. For handling during shipment, lifting irons, eye bolts, or other lifting aids shall be bolted to the housing and shall not be removed until the equipment is in final position. The shipping sections may consist of completely assembled structures or sections of one or more units, as required to suit the handling facilities.

1.10 GUARANTEE

A. Guarantee that all equipment meets the design and performance requirements specified. Alter and/or replace at not cost to the Owner, any piece of equipment which fails to meet these requirements, including any work and factory training supervision necessary.

B. Warrant all material included here to be free from defects for a period of one year from the date of final acceptance of the Building by the Owner. Final acceptance of the building to be determined at latter date. Replace any parts found defective due to manufacture and reinstalled at not cost to the Owner.

PART 2 - AIR HANDLING UNITS

2.1 GENERAL

A. Furnish and install as shown on the drawings air handling unit fans as scheduled. The details outlined in the following specification are considered necessary and important by the engineer. Any deviation from the specification must be approved point by point and in writing one week before bid date. All units shall be manufactured in accordance with this specification even where techniques are required which are not considered standard by that manufacturer.
B. Consider all space limitations indicated on drawings in selection of units.

C. Provide motors, coils, drives, lubricated bearings, filters, fans, inlet vanes, dampers, insulation, mixing boxes, access sections, sound attenuator section, diffuser section, painting and adhesives meeting requirements set forth in other paragraphs of this specification and as shown on drawings.

D. Provide for installation of vibration isolation as set forth in other paragraphs of this specification.

2.2 ARRANGEMENT

A. Each unit shall consist of the combination of modules as shown on the enclosed sketches.

B. Outdoor units shall comply with unit construction specification and the combination of modules as shown on the enclosed sketches.

2.3 UNIT CONSTRUCTION

A. Unit Base

1. The unit base shall be constructed on an all-aluminum structural base. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.

2. The unit base shall be provided with a fully welded sump (minimum 2” depth) in the (1) outside air intake areas; (2) cooling coil condensate area; (3) heating coil area. Sumps to be of aluminum construction welded and guaranteed waterproof. Each area shall include an aluminum cleanout floor drain extended through the unit base.

3. The base floor shall be minimum 1/8” thick aluminum plate welded at all joints and to structural members. Floor material shall have safety-tread surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. The base floor is to be supported with adequate stiffening members to prevent oil canning. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.

4. The perimeter support members shall be 10” structural members properly sized to support all major components and the housing during rigging, handling and operation of the unit.

5. The underside of the base pan, floor and base perimeter shall be insulated with minimum 2” thick 1.5-pcf high density polyisocyanurate foam insulation. A 0.040” thick aluminum
sheet attached to the bottom of the base shall protect insulation.

6. Each section of the unit base shall contain a minimum 1” NPT drain to facilitate system wash down. Drain shall be of aluminum. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.

7. All equipment within air handling unit shall be provided with a minimum 2” high base to raise equipment off unit floor for housekeeping. Equipment mounted directly on unit floor is unacceptable.

8. Air openings shall be framed with 2” high water dam continuously welded to the floor to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot. Galvanized or painted steel grating will not be accepted.

9. All unit base service openings shall be framed with a minimum 2” high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel.

10. Fastening to floor plate or joining of unit sections shall be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners, which penetrate base floor plate, are not acceptable.

11. Unit shall be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

12. After construction, the base shall be cleaned, primed with a rust inhibiting primer and finished with rust inhibiting exterior enamel (rustoleum or equal).

13. Modules shall be manufactured and shipped in a single shall be suitable to withstand rigors of shipping and rigging.

B. Casing

1. Air handling unit casing shall be built up from the unit base with panels. The unit manufacturer shall be the manufacturer of the panel system. Panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets.
The rivets shall have an aluminum cover caps. Plated fasteners will not be accepted.

2. All panels shall be double wall all-aluminum construction with minimum 0.040” exterior and interior skin thicknesses. The finish of the interior panels shall be smooth, mill finish; the finish of the exterior panels shall be a low-reflective textured mill finish. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panels shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

3. Panel system shall incorporate an integral thermal break system such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. Adhesive tapes or gaskets do not constitute an acceptable thermal break.

4. The minimum panel thickness shall be 2-1/2” thick with 3-pcf high density polyisocyanurate foam insulation. Panel shall comply with NFPA 90A requirements.

5. Thickness of the panel skin, core density, rib structural frame spacing shall be regulated to eliminate panel pulsation and restrict the maximum deflection to 1/200 of any span at design load of 1-1/2 times the design positive or negative pressure plus snow and wind loading. Casings shall be built to meet or exceed AMCA Class “C” requirements.

6. All casing walls shall be of panel construction, including but not limited to the fan discharge walls, mixing section walls and divider wall to the access corridor. Corner pieces shall be made of extruded aluminum and filled with 3 pcf high density polyisocyanurate foam insulation.

7. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.

8. All ductwork penetrations through unit enclosure shall be provided with framed openings of size indicated on drawing. Openings shall be provided with flanged duct connections of same material as casing interior extending a minimum of 4” from surface of unit casing.

9. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension shall not be acceptable. Penetrations shall include aluminum cover plates.
10. Removable access panels shall be provided where component removal is not possible through an access door. Access panels shall be of the same construction as panels described above. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels. Airtight integrity must be maintained.

11. Panel joints and seams when required shall be sealed with an FDA approved sealant.

12. If it is necessary to ship the units in sections, due to rigging or shipping constraints, the unit shall be designed to minimize the number of sections. The connections between sections shall be made using extruded aluminum flanged shapes with integral thermal breaks. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. The sections shall be bolted together. For units to be used in production facilities, laboratories, etc., the flange at the connection between sections shall stand to the outside of the unit. For units to be used in offices, etc., the flange at the connection between sections shall stand to the inside of the unit.

13. Instrument, testing and balancing (T&B) holes shall be provided upstream and downstream of all coils and filters for pressure and temperature measurement and where shown on the drawings, or specified in the Data Sheets. Instruments and T&B holes shall be Air Enterprises standard test port, 1" long, with screwed cap.

C. Access Doors:

1. Provide minimum 18” wide access doors for access to all internal components. Access doors shall be installed to open against the greatest pressure relative to air pressure on each side of access door.

2. Access doors shall be of the same no-through metal construction as the panels described above.

3. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place. Single gasket seals will not be accepted.

4. Each access door shall contain a thermopane safety glass window (min. 10” square).

5. Each access door shall be mounted with a stainless steel continuous piano hinge and shall have at least two (2) non-corrosive handles operable from either side.
D. Drain Pan:

1. Full length drain pans shall be provided in the unit base for each bank of cooling coils. The drain pan shall be built into the base of the unit. The drain pan shall be of aluminum construction welded, tested watertight. The minimum depth of the pan shall be 3”, and the width 24”. The drain pan shall be double sloped (minimum ¼” per foot) toward the unit drain.

2. Where cooling coils are stacked, intermediate full length drain pans shall be provided. These pans shall be provided with downcomers draining individually to the unit base drain pan. The downcomer shall be minimum 1-1/4 diameter, made of stainless steel or copper.

3. Intermediate drain pans shall be constructed from minimum 16 gauge 304 stainless steel. Intermediate drain pans shall be minimum 1-1/2” deep, extending at least 3” upstream and at least 12” downstream of the coil face.

4. Intermediate drain pans shall be pitched toward the condensate outlet, and all pans shall be installed to be completely self draining.

5. The drain pan at the unit base shall be provided with a drain connection of sufficient size (minimum 1-1/2” dia.) to remove the condensate, and shall be extended to the unit exterior for connection by others. The drain pan condensate outlet shall be at a sufficient height, considering the internal pressure, positive or negative, to permit the installation of a field fabricated pipe seal trap, within the height of the structural member of the unit base.

E. Roofing (outdoor units):

1. Roofs for outdoor units are to be sloped a minimum of 1/4” per foot to assure positive run-off. Roof to peak on door side and drain away from door side.

2. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof. Membrane to be minimum 0.20” thick. The roofing system shall be guaranteed for a minimum of 10 years for parts and one year for labor. Standing seam roofing system will not be acceptable.

3. Unit shall be provided with a non-corrosive rain gutter system with downspouts to guide unit roof water run-off to the building roof. Units incorporating roof systems without controlled water run-off accommodations shall not be acceptable.

4. Intake Hood
a. The leading edge and the sides of the hood shall extend 3" below the bottom edge of the damper section covered.

b. The leading edge of the hood shall be provided with a rain gutter to prevent droplet carryover into intake dampers.

c. Hood assembly shall be provided with an aluminum bird screen.

d. The hood to unit sheet metal joint shall be caulked to prevent water leakage into intake dampers. If hood is shipped as a sub-assembly, sealant shall be supplied for field re-installation and caulking by the contractor.

e. Hoods shall be sized for less than 500 fpm inlet velocity.

F. Coating Methods

1. Equipment surfaces shall be smooth and free of gross contaminants such as heavy scale, rust, sand, blisters, weld splatter, metal chips and abrasive particles.

2. Any material that is hot rolled, pickled and oiled:
   a. Steam clean or phosphatized per Federal Spec. TT-C-490, Type 2.
   b. Apply 2 mils Dry Film Thickness (DFT) minimum Universal Red Primer.
   c. Apply 5 mils DFT Porter M.C.R. 65 H.S. Epoxy.
   d. Apply final coat of 3 mils Porter Hythane 4610 Urethane.

3. Hot Rolled Structural Members:
   a. Sandblast to commercial finish per SSPC-SP6, PS600280, and oil.
   b. Steam clean and phosphatize per Federal Spec. TT-C490.
   c. Apply 2 mils DFT minimum Universal Red Primer.
   d. Apply 5 mils DFT Porter M.C.R. 65 H.S. Epoxy.
   e. Apply final coat of 3 mils Porter Hythane 4610 Urethane.

4. Exterior and interior finish coat catalyzed epoxy. Final DFT (prime and finish) shall be 10 to 11 mils DFT minimum.

5. Where manufacturers other than the vendor are used to supply components, vendor shall clearly detail equivalent painting methods that the subvendor will use.
6. Stainless steel, hot-dip galvanized, plated, and plastic surfaces are to be furnished unpainted. If the vendor proposes galvanized surfaces that are to be welded after galvanizing, then the entire galvanized surface shall be prepared with a wash and painted with a galvanized compatible primer/finish coat paint system. Simple ZRC touch-up of welds is not acceptable.

G. Acoustical Performance

1. The unit shall comply with the Puerto Rico Environmental Quality Board noise emission level limit.

H. Lights, Outlets and Other Electrical Equipment

1. All electrical work shall be installed in full compliance with the National Electric Code, and all local codes and requirements. Where applicable, components shall be UL approved. All wiring and components inside air handling plenums shall be weatherproof and rated for such use. All equipment shall contain a grounding conductor. All electrical work shall comply with the requirements in Specification 16.019 unless otherwise noted herein.

2. Aluminum rigid conduit, minimum 3/4” dia. utilizing compression type fittings. Conduit and wiring for lights, motor, and receptacles shall be mounted on the exterior of the unit except final connection to power conduit drop to the motor. All conduit penetrations in the unit housing and penetrations across the cooling coil sections and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit. Wiring shall be 600 volt rated, type THHN copper, size #12 minimum.

3. Unit manufacturer shall furnish, install and wire a complete lighting system to one (1) identified 120 volt feed location. Lighting system to include light fixtures, switches, and GFCI receptacles.

4. Light fixtures shall be dust and moisture resistant, fluorescent light fixture, (2) 40 watt, cool white, rapid start bulbs with a low temperature starter. Each access section to be provided with minimum of one (1) light fixture. For units wider than 8 feet, provide 2 light fixtures per compartment.

5. Provide a single light switch for the air handling unit. Light switch shall be 20 AMP, single pole, toggle switch in lug type device box with weatherproof cover.

6. At the unit fan section provide a GFCI convenience outlet inside and one outside. The GFCI convenience outlets shall be 20 AMP, NEMA 5-20R, duplex receptacle in lug type device box with weatherproof cover.
7. The air handling unit manufacturer shall furnish, install and wire a fan motor disconnect switch for each fan motor to one (1) identified 460 volt feed location. Final connection to motors shall be made through Sealight flexible conduit. Fan motor disconnect shall be 3 pole, 600V, horsepower rated, heavy duty, non-fused, safety switch with 2 pole control circuit interlock if used in conjunction with variable speed drive. Disconnect switch shall be NEMA 4 for units mounted outdoors, and NEMA 12 for units mounted indoors. Disconnect switches shall be manufactured by Square-D or Cutler-Hammer.

I. Centrifugal Fans

1. All fans shall bear metal identification plates indicating CFM, HP, RPM, SP and size. Fans shall have capacities not less than those shown on the drawings when operating at the static pressure indicated at 70 degrees Fahrenheit and 29.92 inch Hg barometric pressure. Sizes and types of fans shall be as scheduled on the drawings. Fans shall bear the AMCA label.

2. The fans and fan motors shall be directly connected by means of flexible couplings or have belted drives in which one of the pulleys shall be adjustable. See fan schedules for the type of drive. Fan wheels shall be heavily and rigidly constructed and accurately balanced, both dynamically and statically. Vibration is not to exceed 3 mils for 600 to 1000 RPM, 2 mils for 1000 to 2000 RPM and 1 mil over 2000 RPM. Bearings shall be split pillow block tapered roller bearings, Type SKF-22500. Bearings to have AFMBA rating of 200,000 hours of maximum RPM allowed by fan class.

3. Fan wheel shall be of steel construction with air foil blades. The fan shaft shall be of steel, provided with keys and keyways for the fan wheel hub and fan coupling. Fan outlet shall be of ample proportions so that the actual outlet velocity will not exceed that listed in the Schedule and AMCA Ratings. Outlets shall be fitted with removable angles and bolts for attaching flexible connections. Fan housing shall be provided with variable inlet vanes where indicated on the schedule. Fan housing shall be of steel plate construction suitably reinforced with structural steel shaped for required rigidity. Inlets shall be formed to provide smooth, directed air flow quietly. Entire housing shall be mounted on a structural steel base which shall include as an integral part, slide rails for mounting of the motor. Entire base shall be mounted on vibration isolators.

4. A performance curve shall be submitted with each fan showing point of operation on curve; this point shall be at or near point of fan’s maximum efficiency. Each fan shall bear certification of testing in accordance with "Standard Test Code for Air Moving Devices" based on AMCA Bulletin number 210.
5. Entire unit consisting of fan, motor, drive, stand and bearings shall be a factory-assembled unit. Motor base shall be an integral part of the fan section.


7. Centrifugal fan shall be provided with inlet screens and an OSHA approved fan drive guard with provision for RPM measurement without removing the guard.

8. Supply air fan shall be provided with AMCA Class II construction.

9. Fan and motor assembly shall be mounted on a structural steel base and shall be vibration isolated from unit base utilizing spring type isolators and neoprene duct connector.

10. The fan motor shall be mounted on an adjustable base. Motor shall be General Electric, Siemens Electric, Reliance or Marathon.

J. Filters and Air Filter Gauges

1. Pre-filter
   a. Panel type, 2 inch deep nominal thickness, dry throwaway medium: Two sets to be furnished loose with air handling units. One is to be used during start-up, test and balance and replaced with second set at occupancy. HVAC contractor to install filters. Frame shall be in extruded aluminum construction and part of after filter frame. Sizes as shown on the schedule.

      1) Efficiency rating for this type of filter shall not be less than 30% (MERV 8) percent by the ASHRAE Weight Arrestance Test.

      2) Filter and frame shall be by the following manufacturer: American Air Filters (AFF).

2. Main filter and after filter
   a. Cartridge type, 12 inch deep nominal thickness, throwaway, of the sizes shown on the schedule. The main filters and after filters shall be furnished loose with the air handling units.

      1) Efficiency rating for this type of filter shall not be less than 90% (MERV 14). Efficiency rating is by the ASHRAE Weight Arrestance Test.

      2) Filter and frame shall be by the following manufacturer: American Air Filters (AAF) with T-frame,
nominal 4 inches, extruded aluminum with stainless steel spring clips, polyurethane foam gaskets, seals, pre-punched. T-frame for the main filters shall accept the 2 inch prefilters.

3) Frame shall be installed in air handling unit by unit manufacturer. Filter cartridges shall be provided loose for installation into unit by HVAC Contractor during start-up, test and balancing.

4) Filter bank shall have vertical reinforcing stiffeners every 48 inches for units over 3 frames high. Filter banks shall be front loading.

5) Filter model to be as shown on the schedules.

3. Roll Filters
   a. Media shall be in roll form, designed for use in automatic dry-type air filters. Rolls shall be 39 5/8" wide on a 1 5/8" I.D. tempered fiberboard core. Maximum outside roll diameter shall be 9" for 1800’ roll or 10" for 2250’ roll. The filter media shall be a nonwoven synthetic fabric made of polyester fibers capable of withstanding continuous operating temperatures up to 350º F and humidity conditions up to 99% R.H. It shall be white in color. The media shall be manufactured as per specifications of American Air Filters “AirMat Type R” or equivalent.

4. MEDIA shall be listed by Underwriters' Laboratories as Class 2.

5. Air filter gauges
   a. Air filter gauges shall be provided across each bank of filters to indicate pressure drop of the filter. The filter gauge shall be Magnehlic Air Filter Resistance Gauge, Dwyer Series 2000 with all accessories or equal as approved by the Owner.

K. Dampers
   1. Dampers shall be low leakage, opposed blade design, capable of withstanding 8” wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.² at 4” wg differential pressure and 2,000 fpm approach velocity.

   2. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals. All linkage must be exposed to ensure easy accessibility for adjustment and maintenance.
3. Dampers shall be Ruskin CD-50, Tamco Series 1000, or approved equal.

4. Damper actuators shall be furnished and factory mounted by the unit manufacturer. Actuators shall be mounted so as to be outside of the airstream, unless approved otherwise by Owner.

5. Actuators shall be Johnson Controls with pilot positioner.

L. Water Coils

1. General
   a. Type, size, dimensions and capacity of coils are shown on the schedules.
   b. Each coil assembly shall have an identification tag permanently fastened to the casing of the coil. All counter-flow coils shall have the direction of air flow plainly marked on the exterior of the casing.
   c. Coils shall be certified as to their testing and rating in accordance with the ASHRAE Standard 33-64 "Method of Testing and Rating Forced Circulation Air Cooling and Air Heating Coils," or ARI 410-81 (or later) Standard for Forced Circulation Air Cooling and Air heating Coils.
   d. Fins should be "flat" or "straight" design for lower air friction and easier cleanability. (As opposed to corrugated designs.)
   e. Coils shall be selected for a maximum fin spacing of 10 fins per inch, except as noted on the schedule.
   f. Fins shall be copper and shall be a minimum of .006 inch thick.
   g. No coil will be allowed to have more than eight rows depth. If more than eight rows are required, two or more coils in series shall be provided.
   h. Coils shall be given degreasing treatment to remove oil.
   i. Each cooling coil shall be mounted on a sheet metal casing furnished with a drain pan.

2. Cooling coils
   a. The coils shall be constructed of staggered 5/8 inch O.D. seamless phosphorized copper tube and shall have a minimum .025 inch wall thickness.
   b. Chilled water coils shall have 16 gauge 304 stainless steel casings and 304 stainless steel center supports.
Chilled water coils shall be individually supported by a stainless steel rack system. The rack shall allow any coil to be removed, without disturbing any other coil.

c. Fins shall be continuous across the entire coil width with tubes mechanically expanded into fully drawn fin collars for secure bonding and permanent spacing.

d. Headers shall be close grained cast iron, formed welded steel drilled and machined to receive tubes, or extra strong wall copper pipe with brazed joints.

1) Tube ends shall be rolled into header tube sheet to form a mechanically tight joint.

2) U-bend ends shall be made up of formed copper U-bends with high temperature silver-brazed joints. The fittings wall thickness shall be the same as the tubes.

3) If welded steel is used, a corrosion-resistant coating must be applied to the exterior surface.

4) Vents and drains shall be provided at the highest and lowest points in the coil.

e. Tubes, fins, headers, spacers, etc., shall be mounted in a die-formed galvanized steel casing of not less than 16 gauge.

1) Casing flanges shall be punched around entire periphery to provide bolt holes for connecting to ductwork or housing sheet metal.

2) Coils over 42 inches in length shall have galvanized steel center support. Coils over 96 inches in length shall have galvanized steel center support. Coils over 96 inches in length shall have two tube supports.

3) Provide sealing strip or equivalent at top and bottom of casing to prevent air bypass and condensate leakage. Where coils are split, provide filler strip on both sides of coil to form airtight connection between coils.

f. Connections to coils shall be IPS with thread protectors (caps or plugs) furnished with coils. Coil connections shall project thru the wall of the housing.

g. Coils shall be suitable for operation at 200 PSIG and 220 degrees Fahrenheit. (The coils shall be tested with a minimum air pressure of 400 PSIG while coil is under water.)
1) Drain pan shall be designed to extend entire length of coil including headers and return bends. Depth of drain pan shall be at least 2 inches. Drain pan shall be insulated. Drain pan shall be 16 gauge galvanized coated internally with bitumastic.

2) An intermediate condensate trip pan shall be provided on all coils over 48 inches high. Intermediate drain pans shall be factory piped to main condensate pan.

3) All cooling coils shall be installed in a vertical position (perpendicular to airflow) to minimize condensate carryover.

h. Cooling coils shall be Aerofin Type C or approved Equal. Approval for alternates shall be requested in writing to the Owner.

3. Heating coils

a. The coils shall be constructed of staggered 5/8 inch O.D. seamless phosphorized copper tube and shall have a minimum .035 inch wall thickness.

b. Fins shall be continuous across the entire coil width with tubes mechanically expanded into fully drawn fin collars for secure bonding and permanent spacing.

c. Headers shall be close grained cast iron, formed welded steel drilled and machined to receive tubes, or extra strong wall copper pipe with brazed joints.

1) Tube ends shall be rolled into header tube sheet to form a mechanically tight joint.

2) U-bend ends shall be made up of formed copper U-bends with high temperature silver-brazed joints. The fittings wall thickness shall be the same as the tubes.

3) If welded steel is used, a corrosion-resistant coating must be applied to the exterior surface.

4) Vents and drains shall be provided at the highest and lowest points in the coil.

d. Tubes, fins, headers, spacers, etc., shall be mounted in a die-formed galvanized steel casing of not less than 16 gauge.

1) Casing flanges shall be punched around entire periphery to provide bolt holes for connecting to ductwork or housing sheet metal.
2) Coils over 42 inches in length shall have galvanized steel center support. Coils over 96 inches in length shall have galvanized steel center support. Coils over 96 inches in length shall have two tube supports.

3) Provide sealing strip or equivalent at top and bottom of casing to prevent air bypass and condensate leakage. Where coils are split, provide filler strip on both sides of coil to form airtight connection between coils.

e. Connections to coils shall be IPS with thread protectors (caps or plugs) furnished with coils. Coil connections shall project thru the wall of the housing.

f. Coils shall be suitable for operation at 200 PSIG and 220 degrees Fahrenheit. (The coils shall be tested with a minimum air pressure of 400 PSIG while coil is under water.)

g. Heading coils shall be Aerofin Type CH or approved equal. Approval for alternates shall be requested in writing to the Owner.

M. Factory Inspection and Testing

1. Each unit shall be assembled at the factory, inspected and determined to be in compliance with the specifications. Any deviations found shall be corrected.

2. Owner reserves the right to visit the factory and inspect the equipment prior to shipment. The vendor shall notify the owner 2 weeks prior to shipment when the equipment will be ready for inspection. Deviations identified during the inspection shall be corrected.

3. Pipe systems and coils shall be hydrostatically or pneumatically pressure tested at one and one-half times the maximum operating pressure.

4. All the unit electrical devices shall be energized as components to insure operational integrity prior to the unit shipment.

5. The casing leakage test shall verify that unit casing leakage is less than 1% of design air flow at 1-1/2 times the design static pressure. The unit shall be sealed; pressure sections shall be put under positive pressure and suction sections shall be put under negative pressure. The leakage shall be measured in each section using a calibrated orifice plate. The total casing leakage (positive plus negative) shall be considered the sum of the positive and negative leakage. Air leakage test reports shall be submitted to the Owner.
6. The unit fans shall be operated at the design RPM and a complete vibration spectrum analysis shall be conducted. Such tests shall be performed on a completely assembled unit including all components (fan, motor, base, belts, vibration isolators, etc.). Record the vibration spectrum in the horizontal, vertical, and axial direction at each fan and motor bearing. The vibration spectrum plot for speeds from 30% of specified operating speed to maximum shall indicate no readings of velocity amplitude exceeding 0.10 inches/second. Vibration test reports shall be submitted to the Owner.

7. Unit manufacturer shall demonstrate that the actual performance matches scheduled unit performance by testing and operating unit at the design conditions; simulating external static pressure (providing for dirty filters and wet coils). Test shall include measurements of CFM, BHP and RPM at design TSP.

8. Factory testing shall assure the Owner that any potential system performance concerns are addressed in the factory before unit shipment. Any unit modifications necessary as a result of factory testing not meeting specified performance levels shall be done by the unit manufacturer at no additional cost to the owner prior to unit shipment. A formal written report including all test procedures and accepted results shall be submitted to the Owner.

9. The Owners representative shall have the option to witness all tests. The manufacturer shall notify the Owners representative two weeks prior to the scheduled factory tests. The Owner will inform the manufacturer if a representative will witness the tests.

NOTE: THE ATTACHED APPENDIXES ARE PART OF THIS SPECIFICATION.

END OF SECTION
APPENDIX I

AIR HANDLING UNIT DATA SHEET

AIR HANDLING UNIT NO. _____

1.0 GENERAL

1.1 Manufacturer
1.2 Model No.
1.3 Shipping Weight
1.4 Operating Weight
1.5 Overall Dimensions
   a. Length
   b. Width
   c. Height
1.6 Casing inside skin gauge and material
1.7 Casing outside skin gauge and material
1.8 Panels thickness
1.9 Panels insulation type
1.10 Insulation U factor
1.11 Delivery from receipt of order(weeks)

2.0 FAN DATA AND PERFORMANCE

2.1 Manufacturer
2.2 Model No. and arrangement
2.3 Wheel size
2.4 Class
2.5 Rotation and Discharge arrangement
2.6 Operating speed
2.7 Maximum allowable speed
2.8 Performance curves at specified operating point (attach curves)
2.9 Capacity (SCFM)
2.10 Unit S.P. (inches w.g.)
2.11 Total S.P. (inches w.g.)
2.12 Maximum outlet velocity (FPM)
2.13 Sound power level spectrum (attach curves)
2.14 Bearing types and model numbers
2.15 Fan BHP
# APPENDIX I

## AIR HANDLING UNIT DATA SHEET

### AIR HANDLING UNIT NO. _____

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APPENDIX II
AIR HANDLING UNIT DATA SHEET
COOLING COIL NO. _____

1.0 GENERAL

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2.0 FAN DATA AND PERFORMANCE

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