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SECTION 230000 – MECHANICAL GENERAL CONDITIONS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Should a conflict arise between Section 230000 General Conditions and other Sections, the General and Supplementary Conditions of Division 1 shall take precedence.
- C. The mechanical work shall comply with all provisions of the architectural, plumbing, fire protection, mechanical and electrical drawings and specifications.
- D. The word "Contractor" as used in these specifications shall mean the person, firm or corporation contracting to do the described work.
- E. It shall be a part of this Contractor's bid that the submission of a proposal carries with it the agreement to all items and conditions referred to in the specifications and accompanying drawings.
- F. Rough-in for and connect, as shown on the drawings, facilities for equipment furnished by the Owner under a separate contract.

1.2 RULES AND REGULATIONS

- A. The rules, regulations, ordinances of all applicable governing bodies in force at the time of execution of the Contract shall become a part of these specifications. These shall include the requirements of state, county, city and also the local utility companies.
- B. All materials furnished and work performed shall be in compliance with the latest applicable version of the following codes:

International Building Code - 2015
National Electrical Code - 2014
International Mechanical Code - 2015
International Fuel Gas Code - 2015
International Energy Conservation Code - 2015

1.3 PERMITS AND FEES

- A. Cost of all fees, permits or licenses that may be required for the performance of the Contract shall be included.

1.4 PLANS AND SPECIFICATIONS

- A. The specifications and the accompanying plans (architectural, site, structural, mechanical, electrical, fire protection and plumbing) are mutually explanatory and anything described or shown on one, but not on the other, shall be considered as if shown or described on both. The intention of the plans and specifications is to provide complete functioning systems in every respect. Contractor shall furnish all material and equipment and shall perform all labor to achieve this intent, whether or not such material or equipment is indicated herein. Whenever the term "provide" is used, it shall mean "furnish and install." If a conflict exists between the drawings and the specifications or between one specification and another specification or between one drawing and another drawing, the most demanding requirement shall apply unless otherwise authorized in writing by the Engineer.
- B. Data given herein and on the drawings is as exact as could be secured. Their absolute accuracy is not guaranteed and this Contractor shall obtain and verify exact locations,

measurements, levels, space requirements, etc., at the site, and shall satisfactorily adapt the work to actual conditions at the building as constructed.

- C. The drawings shall be considered schematic and are not intended to indicate all changes in direction and necessary fittings to be installed by this Contractor. Ductwork, equipment, etc., shall be installed so all items clear the structure and other building elements and maintain appropriate clearances for access, service and maintenance.
- D. Some of the details on the plans are schematic or diagrammatic. These details are not intended to show all duct, fittings, etc., required to achieve the arrangement shown on the plan view, but instead are intended to show those items, such as curbs and sealing, etc., which are not shown on the plan view. This Contractor shall appropriately adapt these details to the actual conditions of the job.
- E. Routing of piping, location of equipment, and location of other devices are shown on plans for general guidance. This Contractor shall coordinate his work with other Contractors and shall provide necessary deviations in routing as far as 10 feet from those shown to provide systems as specified or implied, without interference and pursuant to these requirements at no additional cost to the Owner, Architect or Engineer.
- F. Contractor shall not scale the drawings. Refer to architectural and structural drawings for building construction and dimensions and to room finish schedule on architectural drawings for material, finish and construction method of walls, floors and ceilings in order to insure proper rough-in and installation of contractor's work.
- G. Changes, modifications or variations to the plans and specifications will be issued by the Engineer in writing.

1.5 DISCREPANCIES OR OMISSIONS

- A. During the bidding period, should a bidder find discrepancies or omissions in any of the documents or should he be in doubt as to their meaning, he should at once notify the Engineer who will, time permitting, issue a written instruction in the form of an addendum to all bidders of record. The Engineer will not be responsible for any oral explanations or interpretations of the documents.
- B. During construction, should a discrepancy or omission be found, it shall be brought to the attention of the Engineer at once for resolution.
- C. No changes in contract price will be allowed for minor changes in layout or location required to avoid interferences, obstructions, etc. Contract price changes will be considered only for changes in the scope of the project requirements. All such scope changes and price revisions must be authorized in writing.
- D. If discrepancies are found within the contract documents, the most demanding requirement shall take precedence unless otherwise agreed by the engineer in writing.

1.6 VISITING THE SITE

- A. This Contractor, before submitting bid, shall visit the site and become thoroughly acquainted with conditions under which the work will be performed.
- B. Failure to become fully acquainted with existing site conditions under which the work is to be performed will not be justification for additional compensation after the award of the contract.

1.7 HOISTING

- A. Contractor shall be responsible for hoisting of all materials and equipment furnished or installed under this Section of the Specifications, in accordance with all city, state and federal rules and regulations.

1.8 SHOP DRAWINGS

- A. Contractor shall submit shop drawings in compliance with the General and Special Conditions. Contractor shall field verify exact locations, measurements, and space availability at the site, etc. prior to fabricating materials and shall notify the Engineer of discrepancies in writing.
- B. The Contractor shall submit copies of all required Shop Drawings and material and equipment lists.
- C. Submittals shall be transmitted to SSC Engineering as paper documents, electronic documents via email attachments, or electronic documents via FTP file transfers.
 - 1. All submittals shall include a transmittal form identifying the project name, date, contents of submittal package, and names of subcontractor, manufacturer, and supplier.
 - 2. On an attached separate sheet clearly identify deviations from requirements in the Contract Documents, including minor variations and limitations.
 - 3. Paper submittals shall be sent to

SSC Engineering
Attention: Submittals
18207 Edison Ave.
Chesterfield, MO 63005
 - 4. Emails regarding submittals shall be sent to "submittals@sscengineering.com".
- D. Documents transmitted in paper format shall be sent to the Architect who will forward these to SSC. If approved by the Architect prior to submitting documents, these documents may be submitted simultaneously to the Architect and SSC. SSC will return all documents to the Architect only regardless of how they were transmitted to SSC. Submit four (4) paper copies of all required Shop Drawings and material and equipment lists for the Engineer's and Owner's sole use. The Contractor shall submit additional paper copies that will be required for his own use and the Operation and Maintenance Manuals. The additional copies will be reviewed by the Engineer and returned to the Contractor marked accordingly.
- E. If SSC is the prime consultant and there is no Architect, paper documents shall be transmitted directly to SSC.
- F. Documents transmitted as email attachments shall be sent simultaneously to the Architect and SSC. SSC will return one (1) electronic copy of these documents to the Architect only.
- G. Documents transmitted via FTP file transfers shall be retrieved from the FTP site after SSC has received an email notification that these documents have been posted to the site. SSC will return one (1) electronic copy of these documents to the Architect only unless another procedure is agreed to in writing by the Architect and the Engineer.
- H. Contractor shall review and correct all shop drawings before they are submitted. Shop drawings shall bear the signed and dated approval stamp of this Contractor.
- I. Shop drawings shall include the plan mark used on the plans.
- J. Valve and fitting shop drawings shall indicate the intended service.
- K. Equipment shop drawings shall give capacities at conditions specified and shall include manufacturer's catalog numbers and cuts. Shop drawings shall be clearly marked; shall indicate all accessories, items, conditions, etc., which are being furnished; and shall indicate that all conditions of the plans and specifications are being met. Wiring diagrams shall be submitted.
- L. Submittals which do not provide the required information will be returned unchecked.

- M. Contractor shall be responsible for deviations, errors and omissions, quantities, and coordination dimensions in submittals, and this responsibility shall not be relieved by Engineers' review of submittals.
- N. This Contractor shall coordinate each submittal with the contract documents, work of other contractors, and job site conditions.
- O. The Contractor shall not be relieved of responsibility for deviations from requirements of the Contract Documents by the Engineer's approval of Shop Drawings, Product Data, Samples or similar submittals unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submittal and (1) the Engineer has given written approval to the specific deviation as a minor change in the Work, or (2) a Change Order or Construction Change Directive has been issued authorizing the deviation. The Contractor shall not be relieved of responsibility for errors or omissions in Shop Drawings, Product Data, Samples or similar submittals by the Engineer's approval thereof.

1.9 OPERATING AND MAINTENANCE INSTRUCTIONS AND MANUALS

- A. Upon completion of the job, the installing contractors and major suppliers shall instruct the Owner's representatives in the proper operation and maintenance of the systems installed. The installing Contractors shall submit documentation indicating the date of instruction; names and organization of persons providing and receiving the instructions; systems the instructions covered; and materials received.
- B. Contractor shall also submit four (4) complete hard copy sets and one (1) electronic copy of properly bound operating manuals to the Engineer for review. These manuals shall include the following:
 1. Include a Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
 2. Complete set of shop drawings.
 3. Copies of all submittals.
 4. Parts lists, wiring diagrams, piping diagrams, etc.
 5. Manufacturers' operating and maintenance instructions.
 6. As-built drawings.
 7. Written operating and maintenance instructions for the system. This is a written version of Paragraph "1" above.
 8. Copies of warranties.
 9. Parts lists for each piece of equipment and name of local supplier.

1.10 AS-BUILT RECORD DRAWINGS

- A. During construction, a separate set of plans at the jobsite shall be maintained by the Contractor to keep a record of all changes of locations. See additional requirements in General Conditions and Supplementary Conditions.
- B. Locations of piping, ductwork and other concealed facilities are to be shown by the Contractor if and when they differ from the drawings. Underground piping shall be dimensioned on those drawings.
- C. "As built" drawings are to be submitted to Architect/Engineer for review prior to the time of request for final payment. Submit as-built record drawings in accordance with the General Conditions.
- D. For drawings that SSC has furnished to the contractor in CAD format, contractor shall prepare "As Built" drawings in CAD format. "As built" drawings in CAD format are to be submitted to Architect/Engineer, in addition to marked up paper documents for review prior to the time of

request for final payment. Submit as-built record drawings in accordance with the General Conditions.

1.11 GUARANTEE AND WARRANTY

- A. This Contractor shall guarantee and warrant all equipment, materials, workmanship, installation, etc., for a period of one year in accordance with the General Conditions. This one-year warranty shall commence on satisfactory completion of final punch list items. Satisfactory completion of the final punch list will be determined by the Engineer. If the Owner accepts a portion(s) of the project earlier than the rest, such as partial beneficial occupancy, that portion's warranty shall begin on the date it is accepted as substantially complete. A project may have multiple warranty periods in these certain cases and will be fully coordinated between the Owner, the Architect and the Engineer.
- B. During the guarantee period, this Contractor shall make all required repairs and replacements, and shall provide all necessary service, labor, tools, materials, parts, etc., required at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIAL SUBSTITUTION

- A. Equipment selection has been based on one manufacturer to establish the desired type, style, quality, performance, etc. When other manufacturers are listed as equally acceptable, the product of those manufacturers will be accepted if their product complies with these specifications and drawings. The listing of a manufacturer does not relieve that manufacturer from complying with the specifications and drawings.
 - 1. For manufacturers other than those listed, the Contractor shall prepare and submit to the Architect/Engineer for review, a proposal to provide a substitution. Proposal shall be submitted minimum ten (10) working days before the bid date and written approval shall be received from the Architect/Engineer before including the substitution in the bid. Substantiate that the substitution complies with the intent of the Project Documents and include sufficient information of the changes required so that a judgment may be rendered.
 - 2. Proposal shall include a drawing originated by the Contractor. The design shall show the intended installation to the same level of detail as that of the original design in addition to catalog cut, assembly manual, or other generic documents printed by the manufacturer or their representative.
 - 3. Prior to submitting the proposal, the Contractor shall notify all other contractors whose work is affected and request details and pricing of their respective changes. This information along with the Contractor's details shall be transmitted to the Architect/Engineer for approval.
 - 4. If the proposal is accepted, the Contractor shall compensate other trades which are affected by said proposal.
- B. All equipment and materials are subject to the review and approval of the Engineer and Architect.
- C. All differences in cost involved in using an equally acceptable manufacturer shall be included in this Contractor's bid. This contractor shall be responsible for any and all engineering and installation variations due to the substituted equipment. These include structural, electrical, architectural, plumbing, mechanical, fire protection, etc. changes.

- D. Deviations from these specifications are not solicited and are not encouraged. If a deviation between the specifications or drawings and items bid does exist, then that deviation must be clearly itemized and explained on the bid form.
- E. Solvent based adhesives or sealants shall not be substituted for water based adhesives or sealants.

PART 3 - EXECUTION

3.1 GENERAL

- A. Contractor shall provide all material, equipment, labor, services, and supplies, required to execute all work shown on the mechanical drawings; described in these specifications; or made necessary by the work shown on the drawings and/or described in these specifications.
- B. Contractor shall schedule all work and furnish the required materials in such a manner that the work may progress from start to finish in an expeditious and efficient manner without undue interruption. This Contractor shall also schedule his work to coordinate with the construction staging for this project.
- C. Contractor shall hire the proper trades to accomplish the work described on the drawings or in the specifications.

3.2 COORDINATION OF TRADES

- A. Prior to the fabrication or installation of any materials, Contractor shall review the drawings indicating work to be performed by each trade. If conflicts occur, they shall be brought to the attention of the Engineer for resolution.
- B. If Contractor installs the work without coordinating with the other trades, then, if requested by the Owner, Architect, or Engineer, Contractor shall remove and rework some installed work to resolve a conflict, and such change shall be done at no change in contract price.
- C. The Contractor supplying the equipment shall furnish all motors and components which are part of the equipment.
- D. Control wiring is defined as that wiring which conducts electrical energy at a voltage of less than 100 volts. Interlock wiring is defined as that wiring which performs a control function, but at a voltage of 100 volts or greater. All other wiring shall be considered power wiring.
- E. The Electrical Contractor shall provide power wiring to, and including connection to the equipment. Unless specifically noted otherwise, all interlock wiring shall be provided by the Temperature Control Contractor. Unless noted otherwise, the control wiring shall be provided by the Contractor furnishing the controlled equipment.
- F. Unless noted otherwise, the Electrical Contractor shall provide all starters, disconnects, switches, push-button stations, etc., except those which are furnished with the equipment as a part of a factory-assembled package. Heater elements for overload relays on magnetic motor starters (except the starters factory pre-wired with equipment) shall be sized, furnished and installed by the Electrical Contractor. Magnetic motor starters for mechanical equipment (except starters factory pre-wired with equipment such as chillers and packaged air conditioners) shall be provided by the Electrical Contractor. Magnetic motor starters will be provided with:
 - 1. Auxiliary contacts as required by the interlocks defined on the drawings or in the specifications.
 - 2. Control Power Transformer - 120 volt secondary, minimum 40 Volt Amps.
- G. Each Contractor furnishing motor-operated equipment shall furnish a list of motor characteristics to the Electrical Contractor so that properly sized heater elements may be provided. The list

shall include equipment identification by name and by number, the full load current, locked rotor current, voltage rating, and suggested service factor to compensate for operating duty cycle and ambient temperatures.

- H. Unless specifically noted otherwise, pilot controllers (aquastats, flow switches, pressure switches, etc.) shall be furnished and mounted by the Contractor furnishing the controlled equipment.
- I. Unless specifically noted otherwise, thermal wells for temperature control system sensors shall be provided by the Temperature Control Contractor and installed by the Mechanical Contractor.
- J. Unless specifically noted otherwise, control valves and control dampers shall be furnished by the Temperature Control Contractor and installed by the Mechanical Contractor.
- K. Electrical Work For Mechanical Equipment: Electrical Contractor shall wire all mechanical equipment furnished by various contractors in accordance with the following general provisions:
 - 1. Power wiring from panel to motor controllers, relays, etc., and from controller to motor terminals per equipment manufacturer's wiring diagram.
 - 2. Receive, unload, set and align all separately shipped motors. Adjust and align drive and adjust belt tension.
 - 3. Field lubricate all motors prior to initial operation of same.
 - 4. Install individual motor starters specifically called for to be furnished by other Contractors when not a factory pre-wired component.
- L. HVAC Contractor shall provide the following:
 - 1. All motors, disconnect switches or control devices specifically called for.
 - 2. Automatic control and interlock wiring diagrams as called for in the specifications.
 - 3. Complete and accurate wiring diagrams to Electrical Contractor for all equipment requiring electrical power wiring including motor terminal connection diagrams.
 - 4. Adjustable motor bases and all bolts and nuts required for installation of base and motor.
 - 5. Supervision of Electrical Contractor in lubrication of motors to eliminate possibility of motor starting or operating without proper lubrication and control systems.

3.3 PROTECTION OF EQUIPMENT AND WORK

- A. This Contractor shall, at all times, protect and preserve all materials, supplies, equipment, piping, etc., from damage due to weather, corrosion, dirt, vandalism, theft, etc., and shall further provide all enclosures or special protection as indicated by circumstances.
- B. Should any of the materials, equipment, etc., be damaged as a result of his negligence, then this Contractor shall be held responsible for all such damage and costs incurred for repair or replacement.

3.4 CONSTRUCTION STAGING

- A. See schedule in Division 0 and Division 1. This Contractor shall cooperate with and coordinate to plan and schedule the work to satisfy the schedule.

3.5 EQUIPMENT FURNISHED BY OTHERS

- A. Some pieces of equipment, as indicated in the "Equipment Schedule", will be furnished by the Owner and/or under other Divisions of these specifications. This Contractor shall refer to the "Equipment Schedule" and perform the responsibilities assigned to him.
- B. Start-up of equipment furnished by the Owner or under other Divisions of these specifications shall be the responsibility of this Contractor under the Section assigned the responsibility to receive and set in place or to move and set in place.

- C. Warranties for equipment furnished shall be by the equipment manufacturer.

3.6 MAINTENANCE OF WORK AREAS

- A. During the project, this Contractor shall maintain his work area in an organized manner, shall not allow debris to accumulate, and shall store equipment, tools and supplies in a manner which shall not cause interference with the activities of others engaged on the project.
- B. Open ends of pipe, ductwork, equipment, and specialties shall be kept properly closed during construction and installation so as to avoid contamination.

3.7 CLEANING AND CLEANUP

- A. Upon completion of this work, the Contractor shall clean all pipe, ductwork, fixtures, and equipment. Contractor shall leave all work in a finished, clean, and satisfactory working condition.
- B. Each contractor shall be responsible for his own cleanup to a central location designated by the General Contractor. Contractor shall periodically remove all rubbish, crating, unused material, outfall, and any other debris created by him during the course of the work.

END OF SECTION 230000

SECTION 230010 – BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section covers basic mechanical materials and methods for the systems listed below and applies to work of those sections. Provide Basic Mechanical Material and Methods as indicated and required.

- 1. Mechanical

1.2 RELATED DOCUMENTS:

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.

PART 2 - PRODUCTS

2.1 PRODUCT CRITERIA

- A. Material and equipment shall be the standard product of a manufacturer regularly engaged in the manufacture of the product for at least 5 years.
- B. Products shall be supported by a service organization which maintains an inventory of repair parts and is located within 100 miles of the jobsite.

2.2 MATERIALS AND STANDARDS

- A. All equipment and materials furnished by this Contractor shall be new, and where two or more items of the same kind are required, they shall be the product of the same manufacturer.
- B. All materials, equipment, operations, procedures and installation of all materials and equipment shall conform to:

ADA	Americans with Disabilities Act
ASME	American Society of Mechanical Engineers
UL	Underwriters' Laboratories, Inc.
NFPA	Applicable sections of the National Fire Protection Association
NEMA	National Electrical Manufacturers Association
OSHA	Occupational Safety and Health Administration
NEC	National Electrical Code
AMCA	Air Moving and Conditioning Association
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ARI	Air Conditioning and Refrigeration Institute
ANSI	American National Standards Institute, Inc.
ASTM	American Society for Testing Materials
SMACNA	Sheet Metal and Air Conditioning Contractors' National Association
IPCEA	Insulated Power Cable Engineers Association
HEW	U.S. Department of Health, Education and Welfare
PDI	Plumbing and Drainage Institute
NSF	National Sanitation Foundation
IEEE	Institute of Electrical and Electronic Engineers
AWWA	American Water Works Association

- C. All materials used shall be applied in compliance with the manufacturer's recommendations. If a discrepancy occurs between the application of materials as called for on the drawings or in

the specifications and the manufacturer's recommendations, this discrepancy shall be called to the Engineer's attention before materials are purchased or applied.

D. Abbreviations

1.	ACC	Air Cooled Condenser	53.	DO	Digital Output
2.	AC	Air Conditioning Unit	54.	DS	Downspout
3.	AD	Area Drain	55.	DW	Dishwasher
4.	ADJ	Adjustable	56.	DSD	Duct Smoke Detector Supply
5.	AF	Anti-Freeze	57.	DSR	Duct Smoke Detector Return
6.	AFF	Above Finished Floor	58.	DX	Direct Expansion
7.	AHU	Air Handling Unit	59.	E	Exhaust Register/Grille
8.	AI	Analog Input	60.	EA	Exhaust Air
9.	AO	Analog Output	61.	EAT	Entering Air Temperature
10.	AP	Access Panel	62.	EDB	Entering Dry Bulb Temperature
11.	APD	Air Pressure Drop (In WC)	63.	EJ	Expansion Joint
12.	ASA	Air Separator	64.	ELS	Electrical Contractor
13.	B	Boiler	65.	EWB	Entering Wet Bulb Temperature
14.	BB	Air Blender	66.	EWT	Entering Water Temperature
15.	BDD	Backdraft Damper	67.	EFF	Efficiency
16.	BFP	Back Flow Preventor	68.	ET	Expansion Tank
17.	BHP	Brake Horsepower	69.	ECH	Electric Cabinet Heater
18.	BTU	British Thermal Units	70.	EF	Exhaust Fan
19.	BOD	Bottom of Duct	71.	EG	Ethylene Glycol
20.	BOP	Bottom of Pipe	72.	EC	Electrical Contractor
21.	BOS	Bottom of Steel	73.	EMS	Energy Management System
22.	BW	Backwater Valve	74.	ESP	External Static Pressure
23.	C	Coil	75.	ESV	Emergency Shut-Off Valve
24.	CAP	Capacity	76.	EUH	Electric Unit Heater
25.	CONN	Connected	77.	EWC	Electric Water Cooler
26.	CV	Control Valve	78.	EWH	Electric Water Heater
27.	CC	Cooling Coil	79.	EXT	Existing
28.	CC	Center to Center	80.	EXH	Exhaust
29.	CFM	Cubic Feet per Minute	81.	FA	Fresh Air
30.	CH	Chiller	82.	FCE	Furnace
31.	CHP	Chilled Water Pump	83.	FCO	Floor Cleanout
32.	CHR	Chilled Water Return	84.	FCU	Fan Coil Unit
33.	CHS	Chilled Water Supply	85.	FD	Fire Damper (HVAC)
34.	CI	Cast Iron	86.	FD	Floor Drain (Plumbing)
35.	CL	Center Line	87.	FDC	Fire Department Connection
36.	CLG	Ceiling	88.	FH	Floor Hydrant
37.	CO	Cleanout	89.	FHV	Fire Hose Valve
38.	CPVC	Chlorinated Polyvinyl Chloride	90.	FDR	Filter Drier
39.	CR	Condenser Water Return	91.	FHC	Fire Hose Cabinet
40.	CS	Condenser Water Supply	92.	FIN	Finish
41.	CT	Cooling Tower	93.	FLR	Floor
42.	CU	Condensing Unit	94.	FM	Factory Mutual
43.	CUH	Cabinet Unit Heater	95.	FPM	Feet per Minute
44.	CWP	Condenser Water Pump	96.	FT	Feet
45.	D	Drain	97.	FTU	Fan Terminal Unit
46.	DF	Drinking Fountain	98.	FURN	Furnished
47.	DIA	Diameter			
48.	DB	Dry Bulb Temperature			
49.	DDC	Direct Digital Control			
50.	DI	Digital Input			
51.	DISC	Disconnect			
52.	DN	Down			

99.	FLA	Full Load Amps			Condensate
100.	FOB	Flat on Bottom	152.	MPS	Medium Pressure Steam
101.	FOT	Flat on Top	153.	MSB	Mop Service Basin
102.	FPC	Fire Protection Contractor	154.	MV	Mixing Valve
103.	FS	Floor Sink	155.	MSWB	Main Switch Board
104.	FSW	Flow Switch	156.	NO	Normally Open
105.	FTR	Finned Tube Radiator	157.	NC	Normally Closed
106.	G	Gas	158.	NO.	Number
107.	GAL	Gallons	159.	NF	Non-Fused
108.	GALV	Galvanized	160.	NTS	Not to Scale
109.	GEN	Generator	161.	O	Oil
110.	GI	Grease Interceptor	162.	OA	Outside Air
111.	GC	General Contractor	163.	OED	Open End Duct
112.	GUH	Gas Unit Heater	164.	OS	Oil Separator
113.	GWH	Gas Water Heater	165.	OV	Outlet Velocity
114.	H	Hood	166.	OF	Overflow
115.	H-CW	Hot and Cold Water	167.	P	Pump
116.	HB	Hose Bibb	168.	PC	Plumbing Contractor
117.	HD	Hose Drain	169.	POC	Point of Connection
118.	HR	Hour	170.	PIB	Power Induction Box
119.	HP	Heat Pump	171.	PD	Pressure Drop
120.	HP	Horsepower	172.	PD	Pump Discharge (Steam)
121.	HPC	High Pressure Condensate	173.	PD	Pump Discharge-Steam Condensate
122.	HPS	High Pressure Steam			
123.	HR	Hot Water Supply (HVAC)	174.	PG	Propylene Glycol
124.	HS	Hot Water Supply (HVAC)	175.	PTAC	Packaged Terminal A.C. Unit
125.	HU	Humidifier			
126.	HWP	Hot Water Pump	176.	PVC	Polyvinyl Chloride
127.	HX	Heat Exchanger	177.	R	Return Air Grille
128.	IE	Invert Elevation	178.	RA	Return Air
129.	IH	Intake Hood	179.	RAD	Radiator
130.	IN	Inches	180.	RAG	Return Air Grille
131.	INST	Installed	181.	RD	Roof Drain
132.	IRH	Infra-red Heater	182.	RF	Relief Fan
133.	KW	Kilowatt	183.	RG	Refrigerant Hot Gas
134.	LAT	Leaving Air Temperature	184.	RH	Relief Hood
135.	LDB	Leaving Dry Bulb Temperature	185.	RPM	Revolutions Per Minute
			186.	RP	Recirculating Pump
136.	LWB	Leaving Wet Bulb Temperature	187.	RND	Round
			188.	RL	Rain Leader
137.	LWT	Leaving Water Temperature	189.	RL	Refrigerant Liquid
			190.	RPBP	Reduced Pressure Back Flow Prevention
138.	LRA	Locked Rotor Amps	191.	RS	Refrigerant Suction
139.	LAV	Lavatory	192.	RTU	Roof Top Unit
140.	LPC	Low Pressure Condensate	193.	RV	Relief Valve
141.	LPG	Liquid Propane Gas	194.	S	Sink (Plumbing)
142.	LPS	Low Pressure Steam	195.	S	Supply Air Grille (HVAC)
143.	LWCO	Low Water Cut-Off	196.	SA	Supply Air
144.	MAU	Make-up Air Unit	197.	SAG	Supply Air Grille
145.	MAX	Maximum	198.	SAN	Sanitary
146.	MC	Mechanical Contractor	199.	SB	Shower Basin
147.	MCC	Motor Control Center	200.	SD	Smoke Damper
148.	MD	Motorized Damper	201.	SC	Storm Conductor
149.	MIN	Minimum	202.	SF	Supply Fan
150.	MBH	1000 Btu/Hr.	203.	SW	Switch
151.	MPC	Medium Pressure			

204.	STL	Steel	224.	TWU	Thru Wall A.C. Unit
205.	SG	Sight Glass	225.	TXV	Thermal Expansion Valve
206.	SH	Shower	226.	UH	Unit Heater (Hydronic)
207.	SP	Static Pressure	227.	UR	Urinal
208.	SPC	Sprinkler Contractor	228.	V	Vent
209.	SQ	Square	229.	VAV	Variable Air Volume Box
210.	ST	Storm	230.	VD	Volume Damper
211.	ST	Steam	231.	VFD	Variable Frequency Drive
212.	SV	Solenoid Valve	232.	VTR	Vent Thru Roof
213.	SS	Soil Stack	233.	W	Waste
214.	TC	Temperature Controller	234.	WB	Wet Bulb Temperature
215.	TDR	Time Delay Relay	235.	WPD	Water Pressure Drop (Ft. H2O)
216.	TDV	Triple Duty Valve	236.	WC	Water Column
217.	TG	Transfer Grille	237.	WC	Water Closet
218.	TF	Transfer Fan	238.	WCO	Wall Cleanout
219.	TOP	Top of Pipe	239.	WH	Wall Hydrant
220.	TS	Tamper Switch	240.	YH	Yard Hydrant
221.	TS	Temperature Sensor	241.	ZD	Zone Damper
222.	TSP	Total Static Pressure			
223.	TW	Tempered Water			

2.3 PREFABRICATED PIPE SEALS

A. Seals for Roof Penetrations

1. Prefabricated pipe seals shall have a one piece spun aluminum base with a 5" high roof surface flange sloped for runoff. Unit shall have a PVC boot with graduated widths and adjustable stainless steel clamps. Unit shall withstand expansion, and vibration and shall fit pipe sizes from 1/2" through 10".be heavy-gage, galvanized steel curb with mitered and welded corners; 1-1/2-inch-thick
2. Equal products, complying with these specifications by the following manufacturers are acceptable:
 - a. Pate
 - b. Roof Products & Systems
 - c. Thycurb
 - d. Approved Equal

B. Seals for Floor or Foundation Wall Penetrations

1. Mechanical Seal: Link-Seal or approved equal. A modular mechanical sealing assembly consisting of interlocking rubber links shaped to fill the annular space between the pipe and sleeve; corrosion-protected carbon steel bolts, nuts, and pressure plates. After the assembly is positioned in the sleeve, tightening the bolts shall cause the rubber links to provide a watertight seal between the pipe and the sleeve. Seal assembly shall be sized as recommended by the manufacturer. Provide sleeves of proper diameters.

2.4 FLASHING:

- A. Metal Flashing: 26 gage galvanized steel.
- B. Lead Flashing: 5 lb/sq ft sheet lead for waterproofing; one lb/sq ft sheet lead for soundproofing.
- C. Flexible Flashing: 47 mil thick sheet butyl; compatible with roofing.
- D. Caps: Steel, 22 gage minimum; 16 gage at fire resistant elements.

2.5 MISCELLANEOUS MATERIALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36. Interior applications shall be galvanized steel or black steel. Exterior applications shall be galvanized steel.
- B. Strut systems shall be painted steel equal to B-Line Systems or Unistrut. Where used in exterior applications, the materials shall be galvanized steel.

2.6 ACCESS PANELS SHALL COMPLY WITH THE FOLLOWING:

- A. Access panels shall be constructed of heavy gauge steel with factory applied prime coat of baked enamel.
- B. Panel doors shall be attached to the frame with concealed hinges.
- C. Cam locks shall be provided in not less than the following quantities:

Panel Height (Opposite side of hinges)

0 to 18"	1 cam lock
18-1/16" to 30"	2 cam locks
30-1/16" to 48"	3 cam locks
48-1/16" to 60"	4 cam locks

Panel Width

0 to 18"	No cam locks on top or bottom
18-1/16" to 30"	1 cam lock top and bottom
30-1/16" to 48"	2 cam locks top and bottom

- D. On the panel height, one of the cam locks described above shall be a key operated cylinder lock in lieu of the cam lock. One key shall operate all panels.
- E. Cam locks shall have tamper-proof heads. Provide 10 tools to the owner.
- F. For masonry, tile or wallboard surfaces, provide access panels with extruded aluminum frames, 3/4" border, aluminum piano hinges, screwdriver-operated cam lock, brushed satin aluminum finish. Final painting to match interior decor by others. Paintable finish to be provided when the adjacent construction is paintable.
- G. Access panels will not be required in accessible type ceilings.
- H. For plastered ceiling or wall, concealed flange, recessed door panel to receive plaster by others, continuous hinges, flush latch, white prime coat finish. Final painting to match interior decor by others.
- I. For Fire Rated Partition - Access doors in fire rated walls shall be 1-1/2 hour (B) rated and shall bear the UL label. Doors shall be fabricated of steel and shall be provided with baked enamel prime coat over a phosphate coating. Doors shall be Milcor or approved equal.
- J. For locations concealed from public, snap catch latches may be used.
- K. Manufacturer - Panels shall be equal to Inryco/Milcor type K for plaster, type DW for drywall, type M for masonry.

2.7 SLEEVES

- A. Exterior And Foundation Walls:

1. All piping through exterior walls, new concrete walls, or new foundation walls shall pass through sleeves which shall be large enough to allow for caulking and sealant materials. No sleeves shall be permitted through concrete structural members unless indicated on the structural drawings or approved by the Structural Engineer. Sleeves shall be cut smooth and flush with each side of the wall.
 - a. Sleeves above grade shall be Schedule 40 PVC pipe.
 - b. Sleeves below grade shall be cast iron or Schedule 40 PVC pipe.
2. All piping passing through existing concrete or foundation walls shall pass through core drilled holes which shall be large enough to allow for caulking material.
3. All duct openings through exterior walls shall be sleeved with 20 gage galvanized steel sheet metal with flanges turned away from the opening on both sides unless otherwise indicated on the drawings. Space between sleeve and duct shall be packed with fiberglass and sealed on both sides.

B. Interior Walls And Partitions:

1. Fire Rated Walls:
 - a. Piping through fire rated interior walls and partitions shall pass through either Schedule 40 black steel or 20 gauge galvanized steel sheet metal sleeves (18 gauge sheet metal sleeves shall be installed if required by the U.L. classification). Schedule 40 steel pipe sleeves shall be used when required for structural purposes. Sleeves are not required for automatic control tubing.
 - b. Duct through fire rated interior walls and partitions shall be connected to sleeves with fire dampers. See section 230900, Air Distribution.
2. Non Rated Partitions:
 - a. Concealed Locations: Sleeves are not required for piping or ducts unless otherwise indicated on the drawings.
 - b. Visible Locations except in boiler, utility, or equipment rooms:
 - 1) Openings between duct and wall shall be covered with 24 gage galvanized steel sheet metal angles to form an escutcheon over the opening.
 - 2) Openings between pipes and wall shall be covered with escutcheons. Where required, special deep-type escutcheons shall be used. Escutcheons shall be chrome plated, one-piece or split-pattern, and secured in place.
3. Mechanical Room Walls and other locations indicated on the drawings: Duct openings shall be sleeved with 22 gauge galvanized steel sheet metal with flanges turned away from the opening on both sides. Space between sleeve and duct shall be packed with fiberglass and sealed on both sides.

C. Floors:

1. Piping through floors shall pass through schedule 40 carbon steel pipe sleeves, extending from the bottom of the slab to 2 inches above floor.
2. For existing concrete floors an oversized hole shall be core drilled. A flange shall be welded to the outside of the sleeve and the sleeve grouted in place. See details on the plans.

2.8 BACKING & SEALANTS:

- A. Backing and sealant for piping and ducts passing through floors, plaster ceilings, partition, and walls shall be as follows:
1. Backing Material:
 - a. A pure ceramic fiber made of alumina-silica; "Cerafiber- FS" by Manville or equal.
 - b. Insulation: Glass fiber type, non- combustible.
 2. Sealant: Gun Grade. An 1-part neutral- and basic-curing Silicone sealant, "790" by Dow Corning Corporation;"Spectrem 1 (Basic)" by Tremco, or SilPruf LM SCS2700 by GE Silicones.
 3. Mechanical Seal: Link-Seal or approved equal. A modular mechanical sealing assembly consisting of interlocking rubber links shaped to fill the annular space between the pipe and sleeve; corrosion-protected carbon steel bolts, nuts, and pressure plates. After the assembly is positioned in the sleeve, tightening the bolts shall cause the rubber links to provide a watertight seal between the pipe and the sleeve. Seal assembly shall be sized as recommended by the manufacturer. Provide sleeves of proper diameters.
 4. Fire Retardant Sealants: Products used shall be U.L. Classified and approved for the application. Products shall produce non-toxic fumes and shall be PCB and asbestos free. Subject to compliance with requirements, provide fire retardant sealant products from one of the following: 1) "SpecSeal" by Specified Technologies Inc. 2) 3M, 3) Chase Technology Corporation, 4) Link-Seal, 5) Pyro-Pac by Thunderline Corporation, 6) "Fyre Seal" by Tremco, 7) Pensil 100 by General Electric, 8) Pensil by STI, or 9) "Flameseal" by G. S. Nelson Electric.
 - a. Acrylic 1-part silicone rubber, gun applied, fire retardant elastic sealant, "Fyre Seal" by Tremco.
 - b. Silicon foam sealant, CTC PR-855 by Chase Technology Corporation.
 - c. Fire stop putty. "Flameseal" by G. S. Nelson Electric.
 - d. Intumescence Sealant (SpecSeal SSS100) shall be one-part, two stage intumescent latex compound, expands a minimum of 8 times when exposed to 230°F to >1000°F, thixotropic. Sealant shall be capable of caulking or troweling on to vertical surfaces or overhead. Sealant shall be water-based, sandable, paintable, red in color, and safe for contact with plastics.
 - e. Flexible Sealant (SpecSeal LC150) shall be one-part, latex-based compound, flexible and non-shrinking when dry, thixotropic. Sealant shall be capable of caulking or troweling on to vertical surfaces or overhead. Sealant shall be water-based, sandable, paintable, blue in color, and safe for contact with plastics.
 - f. Flexible Silicone Sealant (SpecSeal Pensil 300) shall be one-part, neutral curing silicone, completely water resistant, contain no solvents nor inorganic fibers, allow movement of +/-50%. Sealant shall be auto-bonding, ozone and UV resistant, chemical resistant and capable of caulking or troweling on to vertical surfaces or overhead.
 - g. Intumescence Putty (SpecSeal Firestop Putty) shall be one-part, two stage intumescent, non-hardening compound, expands a minimum of 5 times when exposed to 230°F to >1000°F. Putty shall be soft and pliable with aggressive adhesion, contain no water-soluble intumescent ingredients, water-based, sandable, paintable, red in color, and safe for contact with plastics.

- h. Putty Pads (SpecSeal Firestop Putty Pads) shall be one-part, two stage intumescent, non-hardening compound, expands a minimum of 5 times when exposed to 230°F to >1000°F. Putty shall be soft and pliable with aggressive adhesion, contain no water-soluble intumescent ingredients, water-based, sandable, paintable, red in color, and safe for contact with plastics.
 - i. Pillows (SpecSeal Firestop Pillows) shall be an intumescent pillow heat sealed in a fire-retardant poly bag with a monolithic core encapsulated by flexible intumescent coating and shall expand when exposed to 230°F to >1000°F.
 - j. Mortar (SpecSeal Firestop Mortar) shall be light weight, fast drying, portland cement based, wet mortar density shall be ≤52 lb./cu.ft., dry mortar density shall be ≤45 lb./cu.ft., approved for combustible and noncombustible penetrants, have chemical adhesion, and be red in color.
 - k. Silicone Foam (SpecSeal Pensil Silicone Foam) shall be two-part, silicone, room temperature curing foam, completely water resistant, contain no solvents nor inorganic fibers, allow movement of expansion, contraction and vibration.
 - l. Intumescent Collars (SpecSeal Firestop Collar) shall be factory assembled collar utilizing a molded two stage flexible intumescent insert, insert shall expand a minimum of 15 times when exposed to 230°F to >1000°F, suitable for CPVC, ABS, ABS Foam Core, and FRPP pipes.
 - m. Intumescent Wrap Strips
 - 1) (SpecSeal Firestop Red Wrap Strip) shall be highly flexible, two-stage intumescent material and shall expand a minimum of 15 times when exposed to 230°F to >1000°F.
 - 2) (SpecSeal Series Blu Wrap Strip) shall be highly flexible, two-stage intumescent material and shall expand a minimum of 30 times when exposed to 230°F to >1000°F.
 - n. Intumescent coatings (SpecSeal Cable Coating) shall be water based, intumescent coating, expand a minimum of 5 times its dry applied thickness, flexible, water and weather-resistant film, contain no solvents or inorganic fibers. Coating shall be thixotropic and be capable of being applied by brush application or by airless spray.
 - o. Urethane Joint Sealants
 - 1) Subject to compliance with requirements, provide one of the following:
 - a) Pacific Polymers International, Inc.; Elasto-Thane 230 LM Type II.
 - b) Polymeric Systems, Inc.; PSI-901.
 - c) Approved equal.
5. Single-Component, Nonsag, Urethane Joint Sealant: ASTM C 920, Type S, Grade NS, Class 50, for Use NT.

2.9 FIRE PROOFING ON STRUCTURE:

- A. Where fire proofing is existing or has been applied to the structure by others and the work of this contractor damages or removes this fire proofing while making attachments to the structure, this contractor shall include cost to repair the fire proofing to its original condition.

2.10 LINTELS:

- A. Unless otherwise indicated on plans, all lintels required for the support of building construction above pipes, boxes, panels, ducts, etc., shall be furnished and installed by the Contractor requiring the opening.
- B. Lintels furnished shall be ASTM A 36 structural steel angles, channels, or tees of proper size and sections for the load being supported.

2.11 CUTTING

- A. Each Contractor shall be responsible for any cutting required for openings for conduits, pipes, ducts, etc., if sleeves or openings are not otherwise provided. Under no circumstances shall any structural members, load bearing walls, or footings be cut without first obtaining written permission from the Structural Engineer. All cutting and patching shall be done at the expense of the contractor requiring the cutting.
- B. Cutting shall be limited to the size necessary for working conditions. When cutting surfaces are difficult or costly to replace, such as glazed tile, wood paneling, etc., each contractor shall obtain the Owner's approval in advance of the cutting and patching.

2.12 PATCHING:

- A. Concrete or concrete block surfaces - Patch the opening with concrete, finished smooth with adjacent surface. Painting is the responsibility of the contractor doing the cutting and patching.
- B. Drywall or plastered surfaces - Patch with filler compound. Painting is the responsibility of the contractor doing the cutting and patching.
- C. Surfaces with finishing materials such as tiled, paneled, stone or marble surfaces - Patch the opening with cement or plaster to the underside of final finishing material. Final patching is the responsibility of the contractor doing the cutting and patching.

2.13 PIPING and EQUIPMENT SYSTEMS MARKERS

- A. Markers shall be by Allen Systems, Inc., W.H. Brady Co.- Signmark Div., Industrial Safety Supply Co., Inc. or equal.
- B. Pipe banding shall consist of 1" wide single tape wrapped completely around the circumference of the pipe or insulation.
- C. All color coding shall comply with ANSI A13.1 1975.
- D. Pipe markers shall be manufacturer's standard pre-printed, semi-rigid plastic, snap-on type or vinyl, pressure-sensitive type with permanent adhesive.
- E. Valve tags shall be brass, plastic laminate, or plastic valve tags that are 1½" diameter or square. Indicate piping system abbreviation in ¼" high letters and sequenced valve numbers with ½" high letters. Provide manufacturer's standard solid brass or plated steel chain, or plated steel S-hooks of the sizes required for attachment of tags to valves.
- F. Equipment markers shall be manufacturer's standard laminated plastic type. Include the following, matching terminology on schedules as closely as possible: 1) Name, 2) Tag Number, and 3) Equipment Service. Provide approximate 2½" x 4" markers for control devices, dampers, and valves; and 4½" x 6" for equipment.

2.14 UNDERGROUND PIPING MARKERS

- A. Tape: Triple-laminate, consisting of aluminum foil, polyester film, and polyethylene, 6" wide.
- B. Colored background, black lettering, two lines wide, and 2" tall letters. Provide different color tape for each piping service.
- C. Acceptable Manufacturer, subject to compliance with requirements: Panduit Corporation.

2.15 CEMENT GROUT

- A. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, non-shrink and nonmetallic, dry, hydraulic-cement grout.
 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 2. Properties: Non-staining, noncorrosive, and nongaseous.
 3. Design Mix: 5000-psi, 28-day compressive strength.

2.16 CONCRETE

A. Reinforcing Materials

1. Reinforcing and Joint Dowel Bars: Deformed steel bars, ASTM A 615, Grade 40, unless otherwise indicated. Furnish metal expansion caps for one end of each dowel bar. Design caps with one end closed and a minimum length of 3" to allow bar movement of not less than 1" unless otherwise indicated.
2. Welded Wire Mesh: Welded plain cold-drawn, ASTM A 185. Furnish in flat sheets, not rolls.

B. Concrete Materials

1. Portland Cement: ASTM C 150, Type II with tricalcium aluminate content of less than 5%.
2. Coarse aggregate shall be clean, hard, durable, uncoated limestone conforming to ASTM C-33. Use size "67" throughout with no more than one percent flint and chert by weight (i.e., when the amount of flint and chert are added together, this quantity shall be less than 1% of the coarse aggregate weight).
3. Water: Potable.
4. Air-Entraining Admixture: ASTM C 260.
5. Water-Reducing Admixture: ASTM C 494, Type A.
6. Membrane-Forming Curing Compound: ASTM C 309, Type I unless other type acceptable to Engineer.

C. Proportioning and Design of Mixes

1. Prepare design mixes for concrete in accordance with applicable provisions of ASTM C 94. Use an independent testing facility for preparing and reporting proposed mix designs. The testing facility may be the same as used for field quality control testing.
2. Submit written reports to Engineer of the proposed mix at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed by Engineer.
3. Design mixes to provide normal weight concrete with the following properties: 3500 psi 28-day compressive strength.
4. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, at no additional cost to Owner and as accepted by Engineer. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Engineer before using in work.

D. Admixtures

1. Use air-entraining admixture. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having air content within following limits: 2% to 4% air.
2. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.

E. Slump Limits

1. Proportion and design mixes to result in concrete slump at point of placement at not less than 1" and not more than 4".

2.17 MISCELLANEOUS MATERIALS

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used. Acceptable manufacturers: Gunnebo Fastening Corp., Hilti, Inc., ITW Ramset/Red Head., or Masterset Fastening Systems, Inc.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Drilled Inserts: Self-drilling expansion shields and machine bolt expansion anchors: permitted in concrete not less than four inches thick. Applied load shall not exceed one-fourth the proof test load listed by the manufacturer. Phillips Red-head, wedge anchors or equal.
- D. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- E. Bolts and nuts, except as required for piping applications, shall be carbon steel in accordance with ASTM A 307 and shall be cadmium-plated, zinc-coated steel, or Type 304 stainless steel. Each bolt shall be provided with neoprene and cadmium-plated steel washers under the heads.

PART 3 - EXECUTION

3.1 EQUIPMENT SUPPORTS

- A. This Contractor shall provide all bases, concrete inserts, anchor bolts, and structural steel to support the equipment, ductwork, piping, etc installed by him. Any equipment legs, guy wire, anchors, etc., or any pipe that passes through the roof shall be sealed by a method approved by the Architect.
- B. Provide concrete housekeeping pads a minimum of 3-½" high, unless detailed otherwise, under all equipment, pumps, etc., in equipment rooms that have piping containing water. The horizontal distance from the equipment support to the edge of the pad shall be at least 2", but not more than 4". All exposed edges of each pad shall be ½" chamfer and all surfaces shall be smooth. The housekeeping pads shall be reinforced with wire mesh and shall be doweled to the floor.
- C. Plywood backboards shall be provided for all wall mounted equipment and controls (with the exception of surface mounted cabinets). Backboards shall be constructed of ¾" plywood grade B-C. The "B" face shall be exposed. All boards shall be painted before attachment of any surface equipment.
- D. Provide prefabricated roof curbs or rails for roof mounted equipment except where otherwise indicated on the drawings.

3.2 PIPE AND DUCT PROTECTION DURING CONSTRUCTION

- A. Protect pipe and duct interiors with plastic plugs or plastic sheeting during construction to protect from moisture, construction debris and dust, and other foreign materials.

3.3 DRIVE AND COUPLING GUARD

- A. Contractor shall provide coupling or belt guards on all drives which do not have guards factory installed. Belt guards shall enclose drive on all sides, shall have a hole for making tachometer readings, and shall comply with requirements of governing agencies including OSHA.

3.4 BUILDING OPENINGS FOR ADMISSION OF EQUIPMENT

- A. Contractor shall ascertain from his examination of the architectural and structural drawings and the facility whether any special temporary openings or supports in the building for the admission of apparatus furnished under the Contract will be necessary. The Contractor shall pay all costs of making such openings or providing such supports.

3.5 CUTTING AND PATCHING

- A. All cutting necessary for installation of the work and any required patching that results therefrom shall be done by the proper trade involved and shall be included in the work of this Contractor. Columns, beams, girders or other structural members shall not be cut. No openings shall be cut without written approval of the General Contractor.
- B. Before cutting or drilling holes in floors, verify the location of reinforcing steel bars and embedded electrical conduits to avoid cutting same. X ray floors where necessary to verify such locations. Contact the Engineer before proceeding with cutting if such obstructions interfere with the locations of planned holes.

3.6 ROOF PENETRATIONS

- A. Any penetration of the roof shall be provided with a roof curb, pitch pocket, or other appropriate roof penetration apparatus as herein described.
- B. Cutting of the metal decking for all unframed openings is the responsibility of the Contractor requiring the opening. Cutting, patching and flashing of roof shall be the responsibility of the Contractor needing the opening. Roof cutting and patching shall be coordinated with the roof installer. The original roof warranty shall be maintained.
- C. When penetrations occur in new roofs, the installation of the roofing materials to the connection and the waterproofing of the roofing at the roof penetration apparatus shall be by the General Contractor. This Contractor shall schedule his work so all roof curbs, etc., are in place when required for installation of roofing.
- D. At all times during construction, this Contractor shall provide temporary covers, enclosures, etc., required at roof openings to prevent injury to personnel and to prevent outdoor elements (water, wind, etc.) from entering the opening.

3.7 FLASHING:

- A. Provide flexible flashing and metal counter flashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.

- B. Provide acoustical lead flashing around ducts and pipes penetrating equipment rooms, installed in accordance with manufacturer's instructions for sound control where indicated on the drawings.

3.8 ACCESS

- A. All control devices, equipment, specialties, valves, plumbing traps, etc., shall be so located as to provide for easy access and proper clearance for operation, maintenance, and repair. Provide access panels where indicated or required.
- B. Where items are located above non-accessible ceilings, in or behind walls, or in other similar concealed areas, contractor whose equipment requires access shall provide access panels.
- C. Contractor shall obtain approval of Architect/Engineer of location of access panels that are not indicated on plans.

3.9 PAINTING

- A. All pieces of mechanical equipment shall be factory finished machinery-grey or standard color as furnished by the manufacturer, or as called for in the technical section. Scratches shall be touched up in the field after equipment is installed with a paint which matches the original color.
- B. All sheet metal plenums that are visible through an air device shall have the inside of the plenum painted flat black.
 - 1. This Contractor shall paint the following items:
 - 2. Items specified under "Demolition and restoration of facilities", Section 230000 shall be painted.
 - 3. Paint ductwork visible behind air outlets and inlets matte black.
 - 4. Paint exterior natural gas and fuel oil piping that is above grade; primer plus one coat yellow enamel.
 - 5. No other painting is required unless specifically called for on the plans.

3.10 SLEEVES AND ESCUTCHEONS

- A. This Contractor shall be responsible for locating, placing and maintaining in proper position all sleeves required for the work. In the event that failure to do so requires cutting and patching of finished work, it shall be done at this Contractor's expense.
- B. Sleeves in foundation walls or footings shall be as detailed on the plans.
- C. Where pipes pass through existing concrete floors or walls, the hole shall be core drilled. If sleeves are shown on the plans or details, they shall be grouted in place.
- D. Where pipes and ducts pass through fire walls, plaster or drywall shall be applied around the outside of the sleeve to seal between sleeve and wall.
- E. The internal diameter/dimensions of sleeves shall be 1" to 2" larger than the outside diameter/dimensions of the pipe, duct or insulation. Insulation shall be continuous through sleeves except for ducts with fire dampers. This space is sufficient to allow some movement of the pipes or ducts without cracking the sealant.
- F. The space between the pipes/ducts and the sleeve shall be sealed as follows:
 - 1. Exterior walls above grade: Caulking shall be applied to a minimum 3" total depth. Sealant shall then be applied on both sides of the wall opening to a minimum ½" in depth, finishing flush with the wall.

2. Exterior walls below grade: The space between the pipe and the core drilled hole or sleeve shall be completely filled. Provide mechanical seal and install in accordance with manufacturer's instructions.
3. Openings in floors or roofs: Caulking shall be applied from the upper side to a minimum depth of 3" recessed ½" below the finished floor or roof. This ½" recess shall then be filled with sealant to flush with finished floor or roof.
4. Interior Non-Rated Walls/Partitions:
 - a. Concealed locations: Limit the size of the space between the wall and the outside of the pipe or duct to 1" maximum. The space between the duct or pipe and the wall may be left open.
 - b. Visible Locations: Openings between duct and wall shall be covered with 24 gage galvanized steel sheet metal angles to form an escutcheon to cover the opening. Openings between pipes and wall shall be covered with chrome plated escutcheons.
5. Interior Fire-Rated Walls/Partitions/Floors/Ceilings:
 - a. Where pipes pass through rated assemblies (walls, floors, ceilings, etc.) the pipes shall be sealed per approved methods to meet U.L. Classifications, see the details on the drawings.
 - b. Where ducts pass through fire rated interior assemblies (walls, floors, ceilings, etc.) the ducts shall be connected to sleeves with fire dampers. See section 230900, Air Distribution and details on the drawings.

G. Shop drawings shall be submitted on all fire resistant materials and methods.

3.11 PIPING AND EQUIPMENT SYSTEMS MARKERS

- A. All piping shall be identified with color coded banding. This color banding shall be applied at the following locations:
 1. Adjacent to each valve.
 2. At each branch or riser take-off.
 3. Where piping goes through floors, walls or ceilings.
 4. On horizontal pipe runs at 80 foot intervals, but not less than one per room.
- B. Pipe marking shall also include printed markers indicating the service and flow arrows indicating direction of flow.
- C. Provide valve tag on every valve, cock and control device in each piping system; exclude check valves, valves within factory-fabricated equipment units, plumbing fixture faucets, convenience and lawn-watering hose bibs, and shut-off valves at plumbing fixtures. List each tagged valve in valve schedule for each piping system and include valve schedule in O & M Manual.
- D. Provide equipment markers on all scheduled equipment. Provide manufacturer's standard laminated plastic markers. Provide approximate 2½" x 4" markers for control devices, dampers, and control valves; and 4½" x 6" for equipment. Include the A) Name and Plan Number and B) Equipment Service, matching terminology on schedules as closely as possible.
- E. Install tape on top of all underground piping within 12" of grade. Locate markers as follows:
 1. Continuously over all underground pipes.
 2. Adjacent to each valve and fitting.
 3. At each take-off.
 4. At each pipe passage to underground.

3.12 LINES AND GRADES

- A. This Contractor shall set all construction stakes required for establishing the lines and grades for underground piping and equipment. He shall assume full responsibility for dimensions and elevations measured from such stakes and reset all stakes displaced or moved while the work is in progress.
- B. This Contractor shall coordinate all elevations and dimensions shown on the drawings with the General Contractor and other subcontractors and report any discrepancies to the Engineer. No work shall be installed until all discrepancies have been resolved.

3.13 EXCAVATION

- A. Excavate, as necessary, for all underground piping as indicated on drawings and/or necessary.
- B. Material to be excavated shall be non-classified and shall include all earth or other materials encountered. The contract price shall cover the removal of all such material to the depth and extent indicated on the drawings and/or herein specified.
- C. Unless otherwise shown, provide separate trenches for each utility. Lay all piping in open trench except when the Engineer gives written permission for tunneling.
- D. Excavation of trenches from surface to top of pipe shall be kept to a minimum but shall be of sufficient width for proper installation of the work. The excavation from bottom of trench to top of pipe shall be not more than twenty (20) inches wider than the outside diameter of the pipe to be laid therein, or where depth of backfill over pipe exceeds ten (10) feet, width of trench at top of pipe shall not exceed $\frac{4}{3}$ of nominal diameter of pipe, plus eight inches. For larger pipe, the bottom of trench shall be shaped to conform to the lower half of pipe, and recesses four (4) inches in length shall be cut for pipe bells as required, to give uniform bearing making certain that the pipe is properly supported throughout. Provide ample excavation under and around all pipe joints to permit proper caulking, sealing, welding or thread tightening.
- E. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, and fittings. Remove projecting stones and sharp objects along trench subgrade.
- F. All excavations shall be properly protected by the necessary bracing and timbers to prevent any cave-ins or injury to adjacent improvements and workmen. The sides of all trenches shall be securely held by bracing or sheeting, which bracing and sheeting shall not be removed until the level of the backfill has reached the point where such removal can be safely carried out. The thickness of the sheeting and the dimensions of the cross-braces, shoes, etc., to be used by this Contractor shall be satisfactory to protect properly the sides of the trench and to prevent injurious cave-ins or erosions.
- G. Grading in the area of the excavation shall be such that it shall prevent surface water from flowing into the excavated trench. Under no circumstances lay, pipe or install appurtenances in water. Keep trench free from water until pipe joint materials have hardened. The presence of ground water in the soil or the necessity of sheeting or bracing trenches shall not constitute a condition for which an increase may be made in the contract price.
- H. Where underground pipes cross, the trench of the lower pipe shall be backfilled with sharp sand, well tamped, to provide bed for higher pipe. Pipes which run parallel and at different levels shall be adequately separated to provide firm bedding for the pipes. Sewer, water and gas pipes shall be run in completely separate trenches, and at least three (3) feet apart at center lines, except as approved by the Engineer. Whenever possible, water pipes shall be installed above sewer pipes and gas piping above water and sewer pipes.

3.14 BEDDING and BACKFILLING

- A. All excavations by this Contractor shall be promptly backfilled.
- B. Trenches for sewers, piping, etc., shall be backfilled for a depth of at least six (6) inches over the top of pipe with sand. Bedding shall be provided in the form of six (6) inches of sand under the pipes. It shall be carefully deposited in uniform layers not exceeding six (6) inches in depth. Each layer shall be carefully and solidly tamped with appropriate tools in such a manner as to avoid injuring or disturbing the completed work. Backfill shall be placed beneath haunches of piping and thoroughly compacted to prevent lateral displacement.
- C. Backfill from 0'-6" above the top of the pipe to the surface shall be with clean on-site materials. Large rocks (over 3/4") or other materials shall be removed. Backfill shall be compacted. Compaction shall be at least 90% measured by the Proctor Test (ASTM D 698). Backfill shall be constructed in uniform layers of approximately 6 to 8 inches in loose dimension. Each layer shall be compacted.
- D. Backfill from 0'-6" above the top of the pipe, sewer, conduit, etc., to the bottom side of sidewalks, parking areas, streets, floor slabs or other paved areas shall be with crushed stone or gravel with maximum size of 1/2".
- E. Do not place fill during rainy or freezing weather or on subgrade softened by rain or thawing action. When filling is interrupted by weather, top surface of fill shall be scarified, recompact, and tested before placing new fill. Each day's fill shall be constructed with a slope that will ensure free and rapid drainage.
- F. If the soils are too wet during construction of the fill, dry by discing or other similar methods. If the soils are too dry during construction of the fill, add water in such a way as to permit uniform dispersion of the moisture through the layer to be compacted.
- G. The Owner shall have the option of requiring compaction tests. If the material tested does not meet these tests, this Contractor shall bear the cost of retesting and remedial work.

END OF SECTION 230010

SECTION 230020 – VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide vibration isolators as indicated for each type of equipment and for piping and duct systems. This section applies to:
 - 1. HVAC System

1.2 SCOPE OF WORK

- A. The following items of equipment shall have flexible duct connections installed at the ductwork connection to the equipment:
 - 1. All air handlers, rooftop units, fan coils units, and variable volume terminals.
 - 2. All exhaust fans, supply fans, relief fans and transfer fans.
 - 3. Flexible duct connections are specified in Section 230900.
- B. The following items of equipment shall have flexible pipe connectors installed at the piping connection to the items:
 - 1. Flexible pipe connectors are specified in the appropriate piping section of these specifications.
- C. Unless otherwise noted on the equipment schedule, all mechanical equipment shall be mounted on vibration isolators to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution to produce reasonably uniform deflections.
- D. All isolators and isolation materials shall be of the same manufacturer and shall be selected and certified using published or factory certified data. Any variance or non-compliance with these specification requirements shall be corrected by the contractor in an approved manner.
- E. Vibration isolation manufacturer shall have the following responsibilities:
 - 1. Determine vibration isolation and seismic restraint sizes and locations.
 - 2. Provide piping, ductwork and equipment isolation systems as scheduled or specified.
 - 3. Provide installation instructions and drawings.

1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Material and Methods.

1.4 DEFINITIONS

- A. IBC: International Building Code.

1.5 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading (Wherever loads are indicated, they shall apply only to outdoor equipment.)
 - 1. Basic Wind Speed: 115 mph.
 - 2. Assigned Occupancy Category or Building Category as Defined in the IBC: II.

3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.6 SUBMITTALS

- A. Product Data: For the following:
 1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Welding certificates.

1.7 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the products indicated on Drawings or a comparable product by one of the following:
 1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Isolation Technology, Inc.
 4. Kinetics Noise Control.
 5. Mason Industries.
 6. Vibration Eliminator Co., Inc.
 7. Vibration Isolation.
 8. Vibration Mountings & Controls, Inc.
 9. Vibro Acoustics
- B. Specification W: 3/4" thick waffle pad shall be made of standard neoprene and shall consist of 2" square modules separated by a thin web. Load distribution plate shall be used as required. Pads shall be Mason Type Super "W".
- C. Specification B: Spring type isolators shall be free standing and laterally stable without any housing and complete with 1/4" neoprene acoustical friction pads between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflections, compressed spring height and solid spring height. Mountings shall be Mason Type SLF.
- D. Specification E: Vibration hangers shall contain a steel spring with a rod isolation bushing that passes through the hanger box. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing thru a 30 degree arc before contacting the hole and short circuiting the spring. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include a scale drawing of the hanger showing the 30 degree capability. Hangers shall be Mason Type 30.
- E. Specification RA: Pipe Riser Resilient Support Anchor. All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions. Anchors shall be Mason Type ADA.

- F. Specification RG: Resilient Pipe Guides. Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements. Guides shall be Mason Type VSG.
- G. Specification H: Double-deflection type, elastomeric hangers fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range. Hangers shall be Mason Type HD.

2.2 VIBRATION ISOLATORS BASES

- A. Specification WSB - Steel Base: Factory-fabricated, welded, structural-steel bases and rails. Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps. Structural Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment. Factory-welded steel brackets on frame to provide for anchor bolts and equipment support and for outrigger isolation mountings. Bases shall be Mason Type K or BMK.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static within specified loading limits.

3.3 INSTALLATION OF VIBRATION ISOLATORS

- A. Except as otherwise indicated, comply with manufacturer's instructions for the installation and load application to vibration isolation materials and units. Adjust to ensure that units do not exceed rated operating deflections or bottom out under loading, and are not short-circuited by other contacts or bearing points. Remove space blocks and similar devices (if any) intended for temporary protection against overloading during installation.
- B. Locate isolation hangers as near the overhead support structure as possible.
- C. Adjust leveling devices as required to distribute loading uniformly onto isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

- D. Install inertia base frames on isolator units as indicated to provide a minimum of 1 inch clearance when frame is filled with concrete and supported equipment has been installed and loaded for operation. Provide 3,000 psi concrete per section 230010 in accordance with manufacturer's instruction to fill base.
- E. The isolation type scheduled shall be provided for the each type of equipment. (Isolators identified as "With Equipment" shall be furnished as an accessory with the equipment and shall be installed by the equipment manufacturer such as for internally isolated air handlers.)

3.4 VIBRATION-CONTROL DEVICE INSTALLATION

- A. Comply with requirements in Section 230010 for installation of roof curbs, equipment supports, and roof penetrations.
- B. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
- C. Piping and Ductwork Restraints:
 - 1. Comply with requirements in MSS SP-127 for piping
 - 2. Space lateral supports and longitudinal supports at no more than the maximum of spacing indicated on the drawings or the local building code.
 - 3. Brace a change of direction as indicated on the drawings or the local building code.
- D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- F. Attachment to Structure: Attachments shall be as indicated on the drawings and the approved submittals. If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- G. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the Architect, Engineer, and Structural Engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.5 ADJUSTING

- A. Adjust isolators on piping after piping system is at operating weight.

- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 230020

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SECTION 230050 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Three phase electric motors.
- B. Single phase electric motors.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Provisions.
- C. Other sections with equipment requiring electric motors.

1.3 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. ANSI/IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
- D. ANSI/NEMA MG 1 - Motors and Generators.
- E. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

- A. Submit product data under provisions of Section 230000.
- B. Submittal shall clearly identify the following features for motors to be powered by a VFD:
 - 1. Nameplate with raised or stamped letters on stainless steel or aluminum nameplate.
 - 2. Class H insulation along with frame and end bells of steel construction OR Class F insulation along with frame and end bells of cast iron construction.
 - 3. Premium efficiency.
 - 4. Rated for VFD and across line starting.
 - 5. Shaft grounding brush or ring.
 - 6. Special magnetic wire windings to withstand 1600 v spikes from IGBT drives per NEMA MG1-31.
 - 7. NEMA Design B.
 - 8. Isolated bearings for motors over 100 hp.
 - 9. Bearing type: Sealed.
 - 10. Bearings L-10 life min. 40,000 hours.

1.5 REGULATORY REQUIREMENTS

- A. Conform to all applicable electrical codes.

1.6 WARRANTY

- A. Provide one year manufacturer's warranty under provisions of Section 230000.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Single phase motors and three phase motors, except motors to be used with variable frequency drives, shall be as manufactured by:
 - 1. Baldor
 - 2. General Electric
 - 3. Marathon
 - 4. Siemens
 - 5. TECO-Westinghouse Motor Co.
 - 6. Toshiba
 - 7. U.S. Motors
 - 8. WEG Electric Motors Corp
 - 9. Approved equivalent

- B. Three phase motors to be used with variable frequency drives shall be as manufactured by:
 - 1. Toshiba model EQP Global SD or equal
 - 2. Baldor
 - 3. General Electric
 - 4. Marathon
 - 5. Siemens
 - 6. TECO-Westinghouse Motor Co.
 - 7. U.S. Motors
 - 8. WEG Electric Motors Corp

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service: Refer to Electrical Section for required electrical characteristics.

- B. Motors: Design for continuous operation in 40°C environment and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, Service Factor, and motor enclosure type. In general, motors smaller than 3/4 HP shall be single phase and motors 3/4 HP and larger shall be 3 phase, 60 cycle service. All motors shall be wound for the voltages indicated. Manufacturer's standard motors will be considered provided they are properly selected for the operating characteristics of the driven machine.

- C. Visible Nameplate: Raised or stamped letters on stainless steel or aluminum indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, Service Factor, Power Factor, efficiency. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor and maximum allowable kVAR for power factor correction capacitors.

- D. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

- E. Bearings: Motors shall be equipped with ball or roller bearings and where conditions of service require; suitable end thrust bearings shall be incorporated in bearing design. All bearings shall be constructed to prevent lubrication leakage into the motor under normal or excess lubrication.
 - 1. Permanently lubricated bearings rated for minimum AFBMA 9, L-10 life of 40,000 hours shall be acceptable except where equipment specifications require grease lubricated motors. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Grease lubricated motors shall be equipped with Alemite or Zerk grease and relief fittings. Lubrication instructions shall be furnished with each motor.

 - 2. Bearings shall have a maximum of 45 deg. C rise at rated horsepower for 4 and 6 pole motors and a maximum of 50 deg. C rise for 2 pole motors.

- F. Explosion-Proof Motors (where indicated): UL approved and labeled for hazard classification, with over temperature protection.

2.3 SINGLE PHASE POWER MOTORS

A. Split Phase Motors:

1. Starting Torque: Less than 150 percent of full load torque.
2. Starting Current: Up to seven times full load current.
3. Breakdown Torque: Approximately 200 percent of full load torque.
4. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
5. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
6. Performance as scheduled below.

B. Permanent-split Capacitor Motors:

1. Starting Torque: Exceeding one fourth of full load torque.
2. Starting Current: Up to six times full load current.
3. Multiple Speed: Through tapped windings.
4. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.
5. Performance as scheduled below.

C. Capacitor Start Motors:

1. Starting Torque: Three times full load torque.
2. Starting Current: Less than five times full load current.
3. Pull-up Torque: Up to 350 percent of full load torque.
4. Breakdown Torque: Approximately 250 percent of full load torque.
5. Motors: Capacitor in series with starting winding; capacitor- start/capacitor-run motors shall have two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
6. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated ball bearings.
7. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.
8. Performance as scheduled below.

D. Single Phase Motor Performance Schedule:

HP	RPM (Syn)	NEMA Frame	Min. Percent Efficiency	Percent Power Factor
< or = 0.25	1800	---	74	89
0.33	1800	---	77	88
0.50	1800	---	78.5	89
0.75	1800	---	82.5	90

2.4 SINGLE PHASE EC MOTORS

- A. EC motors shall be electronically-commutated motors or shall have a minimum motor efficiency of 70 percent when rated in accordance with NEMA Standard MG 1-2006 at full load rating conditions. EC motors shall be totally enclosed, non-ventilated (TENV) and have an adjustable speed range from 500 to 1725 rpm. These motors shall have prelubricated ball bearings and automatic reset overload protection. Motor voltage shall be 120-volt or 208 or 230-volt single phase as indicated on the plans.

1. Motor speed shall be adjustable with an integral potentiometer mounted on the exterior of the motor or with a 0-10 volt DC signal from the building automation system.
Potentiometer or building automation speed control shall be as indicated on the plans.

2.5 Three Phase Power - Induction Motors: (Except for Use with Variable Frequency Drives)

- A. Starting Torque: Between one and one and one-half times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Conform to ANSI/NEMA MG 1 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
- G. Motor Frames: NEMA standard T-frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Sound Power Levels: To ANSI/NEMA MG 1.
- I. Nominal Efficiency: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112. Efficiencies listed are consistent with industry standards for "high efficiency" motors.
- J. Nominal Power Factor: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- K. Motor Performance Schedule:

3 Phase/Energy Efficient/Open Drip Proof

HP	RPM (Syn)	NEMA Frame	Percent Efficiency	Percent Power Factor
1	1800	143T	82	84
1-1/2	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	86	86
5	1800	184T	87	87
7-1/2	1800	213T	88	86
10	1800	215T	89	85
15	1800	256T	91	85
20	1800	256T	91	86
25	1800	284T	91	85
30	1800	286T	92	88
40	1800	324T	92	83
50	1800	326T	93	85
60	1800	364T	93	88
75	1800	365T	93	88
100	1800	404T	93	83
125	1800	405T	93	86

- 2.6 THREE PHASE POWER - INDUCTION MOTORS (FOR USE WITH VARIABLE FREQUENCY DRIVES)
- A. Motors shall be Inverter Rated, Premium Efficiency design and shall be labeled "Inverter Rated" and shall be suitable for a variable torque application with a 20:1 turndown ratio. Nominal efficiency and minimum guaranteed efficiency shall be stamped on the nameplate of the motor.
 - B. Design for continuous operation in 40°C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 Part 31. Manufacturer's standard motors will be considered provided they are properly selected for the operating characteristics of the driven machine.
 - 1. Comply with 31.4.3.1 Starting Requirements: Motors shall be designed to allow both across the line starting and VFD use.
 - 2. Motors shall be rated "inverter-duty" per NEMA Standard, MG1, Part 31.4.4.2.
 - 3. Comply with 31.4.4.3 Shaft Voltages and Bearing Insulation: Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.
 - 4. Shaft Grounding Device: Motors larger than 1 HP shall be provided with a shaft grounding brush or conductive micro fiber shaft grounding ring. Shaft grounding device shall be solidly bonded to the grounded motor frame per manufacturer's recommendations.
 - a. Provide grounding devices by the following manufacturers:
 - 1) Grounding Brush: Sohre Turbomachinery, Inc.
 - 2) Grounding Ring: EST-Aegis.
 - 5. Motors larger than 100 HP shall have electrically isolated bearings in addition to shaft grounding to prevent stray current damage. Insulate both motor bearings to prevent current flow and isolate all mechanical load and/or auxiliary equipment bearings (such as tachometers).
 - C. Starting Torque: Between one and one and one-half times full load torque.
 - D. Starting Current: Six times full load current.
 - E. Power Output, Locked Rotor Torque, Breakdown or Pullout Torque: NEMA Design B characteristics.
 - F. Design, Construction, Testing, and Performance: Conform to ANSI/NEMA MG 1 for Design B motors. Motors shall operate successfully at rated load under the various combination of frequency and voltage variations as specified in NEMA MG 1.
 - G. INSULATION SYSTEM - The winding insulation system shall be rated Class F or better. System components such as slot liners, wedges, and phase separators shall be Class F or class H and the whole insulation system to be of non-hygroscopic materials. Inter-phase insulation paper shall be used.
 - 1. Triple coat magnet wire or advanced design magnet wire shall be used. Wound stators with insulating materials in position shall be oven baked to drive-off residual moisture, then dipped in Class H varnish and baked again to cure the varnish. A minimum of two dip and bake cycles is required.
 - 2. The full load temperature rise (of the windings) when the motor is operated on sine wave power shall be measured by resistance and shall be within Class B allowable limits.
 - 3. The entire insulation system shall be capable of withstanding the 1600V spikes experienced with dV/dt IGBT waveforms as defined in NEMA MG1 -1993, Part 31.

- H. Testing Procedure: In accordance with ANSI/IEEE 112, Test Method B. Load test motors to determine freedom from electrical or mechanical defects and compliance with performance data.
- I. Motor Frames: NEMA standard T-frames and end brackets: grade 25 cast iron.
 - 1. Motors with steel frames are acceptable if furnished with Class H insulation in lieu of Class F insulation.
- J. Sound Power Levels: To ANSI/NEMA MG 1 - 1987 (Revised Jan. 1989).
- K. Nominal Efficiency: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- L. Nominal Power Factor: Meet or exceed values listed below at full load and rated voltage when tested in accordance with ANSI/IEEE 112.
- M. Motor Performance Schedule:

3 Phase/For VFD'S/Premium Energy Efficient/Open Drip Proof or TEFC

HP	RPM (Syn)	NEMA Frame	Min. Percent Efficiency	Percent Power Factor
1	1800	143T	86.5	81
1-1/2	1800	145T	87.5	81
2	1800	145T	87.5	79
3	1800	182T	87.5	79
5	1800	184T	88.5	85
7-1/2	1800	213T	89.5	84
10	1800	215T	90.2	86
15	1800	256T	91.2	82
20	1800	256T	92.4	86
25	1800	284T	93.0	82
30	1800	286T	93.0	83
40	1800	324T	94.1	83
50	1800	326T	94.1	83
60	1800	364T	96.0	85
75	1800	365T	95.0	85
100	1800	404T	95.4	85
125	1800	405T	95.4	86

2.7 NEMA MOTOR SERVICE FACTORS

A. Open Motors

HP	3600 RPM	1800 RPM	1200 RPM	900 RPM
1/6 – 1/3	1.35	1.35	1.35	1.35
1/2	1.25	1.25	1.25	1.15
3/4	1.25	1.25	1.15	1.15
1	1.25	1.15	1.15	1.15
1.5 – 150	1.15	1.15	1.15	1.15

B. Totally Enclosed Motors

HP	3600 RPM	1800 RPM	1200 RPM	900 RPM
1.5 – 150	1.0	1.0	1.0	1.0

PART 3 - EXECUTION

3.1 APPLICATION

- A. Motors located indoors shall be open drip-proof type, except where specifically noted otherwise.
- B. Motors exposed to the outdoors shall be totally enclosed motors unless otherwise indicated.
- C. Cooling tower motors shall be totally enclosed, severe duty motors unless otherwise indicated in the cooling tower specification.
- D. Single phase and three phase motors shall be energy efficient type with performance as indicated above.
- E. Motors powered by Variable Frequency Drives (VFDs) shall be either ODP or TEFC and be premium efficient type with performance as indicated above.

END OF SECTION 230050

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SECTION 230100 – INSTALLATION OF MECHANICAL PIPING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, material, services and related items for the HVAC water systems shown on the plans and/or specified herein. These systems shall include:
 - 1. Condensate Drains
 - 2. Refrigerant Piping
 - 3. Natural Gas
 - 4. Fuel Oil

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation.
- E. Section 230200 - Mechanical Insulation.
- F. Section 230910 - Start-up, Cleaning and Testing.
- G. Section 230930 - Testing and Balancing.

1.3 REFERENCES

- A. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.
- B. ANSI/ASME 31.9 - Building Services Piping.
- C. MSS SP-58-2009. Manufacturers Standardization Society Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation.

1.4 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ANSI/ASME Sec 9.
- C. Welders Certification: In accordance with ANSI/ASME Sec 9.
- D. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.5 SUBMITTALS

- A. Submit the following in accordance with Section 230000.
 - 1. Product data, including installation instructions for each type of support and anchor. Submit pipe hanger and support schedule showing Manufacturer's figure number, size, location, and features for each required pipe hanger and support. Indicate which piping systems each component will be applied to.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58 except as modified herein.
 - 1. Hangers: Types 5 and 12 shall not be used.

6.	Riser Clamp (Heavy Duty)	Fig. (40)
7.	Offset Clamp	Fig. B 3148 (103)
8.	Wall Bracket (Light Duty)	Fig. B 3068 (194)
9.	Wall Bracket (Medium Duty)	Fig. B 3065 (195)
10.	Stand with Base	Fig. B 3088 or Fig. B 3088T (62 OR 63)
11.	U-Bolts	Fig. B 3188 (137)
12.	Structural Attachments:	
	Beam clamps:	B 3031(92), B 3033(93), B 3034(94), B 3050(133), B 3045(217) and retaining straps for seismic applications
	Angle Iron Beam Clamp:	B 3046
	Bar Joist:	B 3059
	Concrete Inserts:	B 2500 (281), B 2505 or 2506(285), or B 3014(282)
	Drilled Inserts:	Phillips Red-head, wedge anchors

2.2 PREFABRICATED PIPE STANDS

- A. See Section 230010.

2.3 MISCELLANEOUS MATERIALS

- A. Steel Plates, Shapes, and Bars: ASTM A 36.
- B. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING

- A. All pipe shall be run parallel to or at right angles to walls, beams or columns. Pipe shall be run as direct as possible, avoiding unnecessary offsets, and maintaining maximum headroom. Shortcut diagonal methods will not be allowed.
- B. Piping drawings are to be considered schematic and are not intended to indicate all changes in direction and necessary fittings to be furnished and installed. Provide reducers/increasers at connections to equipment as required to match the equipment. Pipe and fittings shall be installed so that all pipe and/or insulation completely clears all nearby structures and piping.
- C. All piping shall be supported from the building structures by means of approved hangers and supports. Piping shall be supported to maintain required grading and pitch of lines, to prevent vibration and excessive deflections, and to secure piping in place.
- D. Piping shall be arranged to allow for expansion and contraction. Provide expansion loops, guides and anchors where indicated on the drawings.
- E. Install branch connections to mains using Tee fittings in main with take-off out the bottom of the main, except for up-feed risers which shall have take-off out the top of the main line except branch take-offs shall be made with swing connections where required to avoid stress at these points. Tees shall not be installed in a bullhead arrangement.
- F. At swing connections, offsets, expansion loops, etc., pipes shall be cold sprung into place before welding to compensate for fifty percent (50%) of the expansion.
- G. Pipes shall not be hung from other piping or from equipment of other trades. Hanger rods and piping shall not pierce ductwork.
- H. Pipe supports shall be structurally capable of carrying the pipe or pipes supported by them and shall be capable of vertical adjustment after installation of piping.

- I. Piping at all equipment and control valves shall be supported to prevent strains or distortions in the connected equipment and control valves. Piping shall be installed and supported to allow for removal of equipment, valves and accessories with minimum dismantling and without requiring additional supports after these items are removed.
- J. Install unions in pipes 2-1/2 inch and smaller at final connections to each piece of equipment and at valves, strainers, traps, etc., and elsewhere as indicated. Unions are not required on flanged devices. Install flanges on valves, apparatus, and equipment having 3 inch and larger connections.
- K. Dissimilar metals in the piping system shall be separated with dielectric unions or insulating flange sets.
- L. Provide plugged tees at all low points, except where drain valves are called for to allow for system drainage. All pipe lines shall be pitched to equipment traps and/or outlets. All horizontal mains shall be graded to have a pitch of at least 1" in 40'-0" in the direction of flow unless otherwise noted. Eccentric couplings, pitched fittings, etc., shall be installed where necessary to eliminate pockets.
- M. Provide manual air vents at all high points to allow bleeding of air from the system. Where gauge cocks are shown at coils, etc., these gauge cocks may serve as the air vent at that location.
- N. Factory fabricated fittings, similar to Bonney Forge Weldolet, Threadolet, Socklolet, or Elbolet may be used for branch connections to mains where branch size is less than main's size.
- O. Welding shall be performed by individuals who are currently qualified under procedures certified as acceptable by the National Certified Pipe Welding Bureau. Individuals must be prepared to provide current qualification certificates upon request. All work shall be done in accordance with the latest revised edition of the ASME Code for Pressure Piping requirements.
- P. Lines subject to rapid changes in flow rate shall be anchored to prevent excessive movement or vibration.
- Q. Drain lines shall be terminated over floor drains to direct the flow vertically into the floor drain. Provide elbows where required. Cut openings in the floor drain strainer where needed to prevent splash-out. Provide clean outs at changes in direction of more than 45 degrees and at maximum 75 feet spacing along the line.

3.2 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Comply with the procedures contained in the AWS "Soldering Manual."
- B. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."
 - 1. CAUTION: Remove stems, seats, and packing of valves and accessible internal parts at piping specialties before brazing.
 - 2. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.
 - 3. Heat joints using oxy-acetylene torch to proper and uniform temperature.
- C. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe fittings and valves as follows:
 - 1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
 - 2. Align threads at point of assembly.
 - 3. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).

4. Assemble joint wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.
 - a. Damaged Threads: Do not use pipe with threads which are corroded or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.
- D. Welded Joints: Comply with the requirement in ASME Code B31.9-"Building Services Piping."
- E. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.
- F. Grooved Joints: Assemble joints in accordance with fitting manufacturers written instructions.
- G. Press-Joint Fittings: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B 16.22 and performance criteria of IAPMO PS 117. All copper press fittings, couplings and specialties shall be the products of a single manufacturer. Installation tools shall be as recommended by the fittings manufacturer.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

- A. Install hangers, supports, clamps and attachments, complete with necessary inserts, bolts, rods, nuts, washers, and other accessories, to support piping from building structure; comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping supported together on field-fabricated, heavy-duty trapeze hangers where possible. Install supports with maximum spacings complying with MSS SP-58.
- B. Install building attachments within concrete or to structural steel. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert to forms. Where concrete with compressive strength less than 2,500 psi is indicated, install reinforcing bars through openings at top of inserts. Where inserts are omitted, drill through concrete slab and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab in locations where nut, etc. will interfere with other work or be a tripping hazard and above slab in other locations.
- C. Hangers and supports shall be provided as required to eliminate vibration and excessive deflection, but in no case over the following centers, unless specifically indicated otherwise on the drawing. Rod sizes for individual pipe lines shall not be less than the following schedule:

(STL = Steel , CU = Copper)

PIPE SIZE (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM ROD SIZE (INCHES)	MAXIMUM HANGER SPACING (FEET)	MINIMUM ROD SIZE (INCHES)
	STL	STL	CU	CU
1/2	7	3/8	5	3/8
3/4	7	3/8	5	3/8
1	7	3/8	5	3/8
1-1/4	7	3/8	8	3/8
1-1/2	9	3/8	8	3/8
2	10	3/8	8	3/8
2-1/2	11	1/2	8	1/2
3	12	1/2	10	1/2
3-1/2	13	1/2	10	1/2
4	14	5/8	10	1/2
5	16	5/8		

6	17	3/4
8	19	7/8
10	22*	7/8
12	23*	7/8
14	25*	1
16	27*	1

*Maximum spacing for insulated pipe shall be 20 feet.

1. An additional hanger shall be installed at every change in direction of piping.
- D. When trapeze type hangers are used to support two or more pipes, rods shall be used for vertical hanger members and angles, channels, Unistrut or tee sections for horizontal hanger members. The material used shall be sized to support the load without excessive deflection. Spacing of trapeze hangers shall be based on the smallest pipe supported on the trapeze hanger. Rod sizes and spacing for trapeze hangers shall be based on supported weight and load carrying capacity of attachment device. Size trapeze bar for allowable loads indicated in SMACNA HVAC Duct Construction Manual (2005), Table 4-3, or as otherwise approved by the Engineer.
 - E. Hanger rods shall have double nuts and lockwashers at all connections.
 - F. Piping at walls shall be supported with wall brackets; vertical pipes shall be supported with riser clamps.
 - G. Contractor shall verify loading on hangers, hanger rods and structural attachments. Loading on the assembly shall not exceed 75% of the manufacturer's rating for any component of the assembly. If loading does exceed the 75%, then hanger spacing shall be reduced.
 - H. Piping shall not be supported from joist bridging or a roof metal deck.
 - I. Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 5 feet apart at valves. Pipe hanger loads in excess of 50 pounds, suspended from steel joists, shall have the hanger loads suspended from panel points. Pipe supports for PVC piping shall be maximum 4 feet on centers. Where local codes require closer spacing than indicated on the plans or specifications, the supports shall conform to the local code requirements. For buildings built with steel joists before 1985, pipe supports shall be attached to the top leg of the joist.
 - J. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 15 feet, not more than 8 feet from end of risers, and at vent terminations.
 - K. Pipe Guides: Type 35 guides using steel reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.
 - L. Steel Slides: Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 4 inches and larger with medium 60 degrees F or greater, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.
 - M. High Temperature Guides with Cradles: Where there are high system temperatures and welding to piping is not desirable, the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 4 inches, or by an amount adequate for the insulation, whichever is greater.

- 3.4 Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6-inch and larger shall be sheet metal. See additional requirements in Section 230010.
- 3.5 Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Section 230010 for sealants and materials.
- 3.6 Provide thermometers, thermometer sockets, and thermal wells where indicated on the drawings or in the specifications. Install in tees or in extra heavy nipples welded to the pipe or as indicated on the drawings. Install thermal wells for temperature control system temperature sensors and where indicated on the drawings. Coordinate the location of temperature sensor wells with the temperature control contractor and the Engineer.
- 3.7 Install control valves and pressure sensors in accordance with the manufacturer's instructions where indicated on the drawings or in the specifications. Install taps and shut off valves for pressure sensors for temperature control system sensors and where indicated on the drawings.
- 3.8 Provide pressure gauges and test plugs where indicated on the drawings or in the specifications.
- 3.9 Dielectric unions shall be provided at the following locations:
 - A. At the connection of copper and steel piping.
 - B. At the connection of steel piping to copper coils.

END OF SECTION 230100

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SECTION 230130 – FUEL OIL PIPING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, material, services and related items necessary to complete the fuel oil piping work indicated on the drawings and/or specified herein. Work to be performed shall include, but not be limited to, the following items:
 - 1. Installation of all fuel oil piping including connections to all equipment.
 - a. #2 oil for the furnace

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation and Seismic Restraints.
- E. Section 230910 - Start-up, Cleaning and Testing.

1.3 REFERENCES

- A. ANSI/ASME Sec 9 - Welding and Brazing Qualifications.
- B. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.
- C. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
- D. ASTM A234 - Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
- E. ASTM B88 - Seamless Copper Water Tube.

1.4 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME 31.9.
- B. Conform to applicable local, state and national codes.

1.5 QUALITY ASSURANCE

- A. Valves: Manufacturer's name and pressure rating marked on valve body.
- B. Welding Materials and Procedures: Conform to ANSI/ASME Sec 9.
- C. Welders Certification: In accordance with ANSI/ASME Sec 9.

1.6 SUBMITTALS

- A. Submit product data under provisions of Section 230000.
- B. Include data on pipe materials, pipe fittings, valves, specialties and accessories. Each submittal shall be clearly marked for the service(s) intended.

- C. Indicate seismic restraint locations including both lateral and transverse bracing on each shop drawings and described on product data. Indicate each restraint type as described on product data.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. All components, including piping, fittings, valves and equipment, etc., used in oil piping system shall be suitable for continuous operating pressure of not less than 125 psig.

B. PIPE MATERIALS (#2 OIL FOR FURNACE AND WATER HEATER):

ITEM	MATERIAL
Pipe	Code (1) or (7) or underground (8)
Fittings	Code (1) (150 lb) or (7)
Unions	Code (1) or (7)
Stop Valves	Code (1)
Check Valves	Code (1)
Vent Pipe	Code (4)
Vent Pipe Fittings	Code (4)

C. Pipe Materials (Below Grade)

- 1. Below ground steel piping shall have factory applied polyethylene coating, ANSI/AWWA C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape. "X-TRU-COAT" by Republic Steel, or equal. Joints, fittings, and any damage to coating shall be repaired with "X-TRU-TAPE" and primer or equal.

D. Pipe

- 1. Code (1) - Carbon steel pipe ASTM-A53/53M continuous weld electric-weld or seamless Schedule 40, USAS B36.10M.
- 2. Code (4) - Carbon steel pipe, ASTM-A120 continuous weld, electric welded or seamless, schedule 40, USAS B31.1, galvanized.
- 3. Code (7) - Type L hard drawn copper, minimum 0.032 inch thick.
- 4. Code (8) - Type K hard drawn copper.

E. Fittings

- 1. Code (1) - Malleable iron, screwed 150 lb. or 300 lb. (see above) Standards: ASA B16.3, threads ASA B2.1; material ASTM A-47 Grade 32510.
- 2. Code (2) – Seamless carbon steel grade B standard weight butt-weld fittings. Standards: ASA B16.9; material ASTM A234.
- 3. Code (4) – Malleable iron, screwed, 150 lb. Standards: ANSI B16.3, threads ASA B2.1; material ASTM A-197.
- 4. Code (7) – Wrought or cast bronze solder type fittings.

F. Unions and Flanges

- 1. Code (1) – Malleable iron unions, 150 lbs. (300 lbs.). Standards: Threads ASA B2.1; material ASTM A-47, Grade 32510, ASA B16.3, Ground joint bronze-to-iron or bronze-to-bronze.
- 2. Code (2) – Forged carbon steel flange weld mech bored to match Schedule 40, 150 lb. ASA-B16.5, raised face, materials ASTM A181, Grade 1.
- 3. Code (7) – All bronze or brass, suitable for 150 psi working pressure.

G. Valves – General

- 1. Each valve shall be shell and seat tested by the manufacturer.

2. All valves of the same type shall be of the same manufacture.
3. Valves shall not contain asbestos.
4. Operator features:
 - a. Handwheels, fastened to valve stem, for valves other than quarter turn.
 - b. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Plug valves shall have square heads; furnish one wrench for every 10 plug valves (minimum 3).
5. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.
6. Shop drawings shall be submitted on all valves. Each submittal shall be clearly marked for the service intended.
7. Model numbers used for each type of valve shall establish the desired type, quality and materials of construction. Products equal to the valve specified and meeting these specifications, by the following manufacturers, are equally acceptable:
 - a. Ball Valves:
 - Nibco
 - Watts
 - Crane
 - Lunkenheimer
 - Stockham
 - James Bury
 - Gemini
 - Contramatics
 - b. Gate Valves, Butterfly Valves, Swing check valves, and Spring check valves
 - Nibco
 - Jenkins
 - Centerline
 - Crane
 - Demco
 - DeZurik
 - Keystone
 - Lunkenheimer
 - Stockham

H. Stop Valves

1. Code (1) - Stockham Model T-255, bronze two-piece body, chrome plated brass or bronze ball, Teflon seats, lever handle, threaded ends.
2. Code (2) - Jenkins Fig. No. 651-A, flanged, solid wedge, IBBN, O.S. & Y. gate valve. 125 psi at 450°F, 200 psi WOG.

I. Check Valves

1. Spring-loaded check valve.

J. Joint Material or Gaskets

1. Code (1) Thread sealing compound compatible with oil (Teflon tape, not allowed).
2. Code (2) - Flanged joints, Garlock or Manville suitable for oil.

K. Flange Bolts and Nuts

1. Code (1) - Carbon steel machine bolts ASTM A-307 Grade A, heavy series hex nuts ASTM A-194 Grade 1, ASA B1.1 and B18.2.

- L. Oil Strainer (#2 oil)
 - 1. Basket strainer shall comply with the following:
 - a. Monel perforated screen with 1/16" perforations.
 - b. Iron construction rated for 200 psi working pressure, hydrostatically tested at 1-1/2 times working pressure.
 - c. Plugged bottom outlet.
 - d. Quick opening, swinging yoke, and gasket.
 - e. Hayward No. 72 or equal.
 - 2. Pressure drop equal to, or less than 0.25 psi with a flow rate equal to the pump capacity of oil at a viscosity of 75 S.S.U. Strainer shall not be less than full line size.
- M. Strainer
 - 1. Bronze body with bronze strainer, threaded ends, threaded removable top, Hayward No. 40, or equal.
- N. Oil Pressure Relief Valve
 - 1. Valves for pressure relief due to thermal expansion of oil shall be all bronze construction with 1/2" inlet and 3/4" outlet and shall be set at 250#. Kunkle Figure 20 or equal.
- O. Foot Valve
 - 1. Brass body, threaded, spring loaded poppet with neoprene-to-brass seats. Flow Matic, Clayton Mark & Company, OPW or equal.
- P. Fill Cap
 - 1. Equal to OPW 126, and shall include a watertight manhole with screw on gasketed outer cap, and screw on, lockable inner cap. Furnish wrench for removing outer cap.
- Q. Screen Vent Elbow
 - 1. Equal to OPW No. 23.
- R. Oil Tank Gauge
 - 1. Remote reading oil tank gauge. Gauge shall be Levelometer by Simmonds Precision Industrial Instrument Division, or approved equal.
 - 2. Gauge shall include the following:
 - a. 12" square case with dial calibrated in gallons. Total scale suitable for oil tank specified.
 - b. Built-in hand pump located in gauge case.
 - c. Oil tank fitting and dip tube.
 - d. Transmission tubing.
 - 3. Underground transmission tubing shall be protected by a 1" Schedule 40 PVC conduit using long radius bends where bends are necessary.
- S. Thermometers
 - 1. Thermometers shall be Palmer, Trerice, Weiss, Jay, Marsh, Weksler or approved equal. Thermometers shall be equal to Trerice #BX934031/2 adjustable angle. Red Reading Industrial Thermometers with cast of extruded brass or aluminum closed cases, stainless steel or brass tapered bulbs with bulbs in direct contact with metal, individually calibrated tubes and engraved scales. Each thermometer shall have adjustable angle for

convenient reading and shall be installed in a matching brass separable socket with a 3/4" NPT. The thermometer sockets shall be installed in tees, or in extra heavy nipples welded to the pipe. Stem length of socket shall be 3-1/2" except on lines where the insulation thickness exceeds 3" the stem length shall be 6" with an extension neck socket.

2. Thermal wells in liquid lines shall be of same manufacturer as thermometers with 3/4" NPT, cap and chain, and shall have Government Standard tapered walls to provide for future installation of industrial thermometers. Sockets shall be installed vertically in tees or in extra heavy nipples welded to the piping. Socket length shall be 3-1/2" under hex, except on lines where the insulation thickness exceeds 3", the length shall be 6" including 2-1/2" extension neck.
3. All thermometers and thermal wells shall be by one manufacturer and shall be interchangeable.
4. Graduation of thermometers shall be as follows:

	<u>RANGE (°F)</u>	<u>DIVISIONS</u>
Oil	30 to 240	2°F

5. Submit shop drawings on thermometers and separable sockets.

T. Pressure Gauges

1. Provide pressure gauges where indicated on the drawings or in the specifications. Gauges shall be equal to Terice #600. Equal products by Marsh, Ashcroft, U.S. Gauge, Weksler, Terice are equally acceptable.
2. Gauges shall include the following:
 - a. 4-1/2" diameter
 - b. Closed type ring with clear glass
 - c. Bronze tube, Bourdon type
 - d. Brass movement
 - e. 1/4" NPT bottom connections with brass tee handle cock
 - f. Use pressure "snubbers" at pump discharge locations or other similar locations where gauge needle pulsation might occur.
3. Submit shop drawings on gauges.
4. Graduation of pressure gauges shall be:

	<u>RANGE</u>	<u>DIVISIONS</u>
Oil discharge	0-300 psi	25 psi
Oil suction	0-30" Hg	2"

5. Gauge cocks shall be brass, equal to Terice No. 865 or 880, and shall be provided at all gauges.

2.2 ABOVEGROUND FUEL STORAGE TANKS

A. Manufacturers:

1. Granby
2. Product Code 3020422
3. Other acceptable manufacturers offering equivalent products.

B. Capacity:

1. Volume: 500 gallons.

2. Diameter: 4 feet.
- C. Tank: ASTM A-1011 and UL-142 listed and labeled, double-wall type, steel, on skids, capable of aboveground liquid storage and attachments, fittings, lifting lugs and tappings for accessories. Tank interstitial spaces shall have a space between the walls to allow free flow and contain all leaked product, the space shall allow the insertion of a leak sensor through a monitor fitting.
- D. Tank Fittings: Provide NPT primary tank fittings; 1 each, 2" fill, 2" utility, 2" vent, 2" suction, emergency vent opening and others as detailed.
- E. Filler Cap: 4-inch watertight brass.
- F. Gauge: Remote reading, electronic, for two wire, 24 volt power, monitor wiring with wall mounted gauge. (Combination leak detection and level measurement gauge).
- G. Leak Detector System: Tanks shall have an integrally-mounted reservoir installed for hydrostatic monitoring equipment, including FRP reservoirs and electronic control, shall be UL listed. The system shall be installed complete as detailed tank data including reservoir sensor, containment collar sensor and inventory gauge control panel.
- H. Provide tank gauge probe assemblies, compatible with diesel fuel, as required to monitor fuel level.
- I. Inventory Gauge, Control and Leak Detection:
 1. Provide VEEDER ROOT TLS-350 control panel, UL listed with 8 modules including 3 remote communication modules.
 2. Utilize this panel for combining all tank gauges, alarms and monitoring sensors.
 3. Provide 98 db local alarm bell with alarm silence button.
 4. Provide interconnecting wiring and compatible sensors to assure a complete and operating system.
- J. Overfill Prevention Valve: Aluminum automatic valve designed for underground or aboveground tanks, as applicable. Locate valve near the top of the tank in the fill pipe. On aboveground tanks, or tanks pressure filled, provide single stage valve, rated for fill flow and pressure, which stops flow completely at 95 percent of tank capacity. Valve shall include method for draining oil trapped above the valve into the tank.

2.3 LEAK DETECTION SYSTEMS

- A. Automatic digital continuous monitoring systems responsive to the presence of water and hydrocarbons in the interstitial space of the double-wall tank, in the tank manhole access enclosures, and in the secondary containment of fuel piping systems. System shall distinguish between hydrocarbon and water and identify location of leak as to individual tank and piping system locations. System to be combined with tank fluid level monitor and alarm system specified in level monitor system.
- B. Functions and Arrangement:
 1. Single control station to monitor all sensing probes.
 2. Visual indicator to monitor and identify leaks as water or hydrocarbon and location.
 3. Indicators showing system status including faults and alarms.
 4. Panel circuit test button.
 5. Eight hour memory backup system with battery.
 6. UL or other accredited testing laboratory listing.
- C. Sensors:

1. Designed for required locations including: Insertion between walls of double-wall tanks, in sumps in double-wall piping systems and in tank manhole enclosures. Sensing points shall be at lowest point of each tank or sump. Intrinsically safe design.
 2. Sensing units shall detect presence of water and a minimum 3 mm (0.125 inch) thick layer of hydrocarbon on surface of water and minimum 50 mm (2 inch) thickness of hydrocarbon in area that has no water present.
 3. Sensors shall be arranged to allow replacement of individual sensors without disturbing other portions of leak detection system or fuel storage and piping system. Underground sensors shall be accessed through caps as grade.
 4. Materials of construction shall be non-corroding.
 5. Transmit status signal to control unit.
- D. Manufacturer: Veeder-Root Preferred Utilities, or equal.
- E. Digital systems for central monitoring of fuel and water levels in all fuel oil storage tanks in the project. High and low level visual and audible alarms. Volumetric tank-tightness testing. Complete with all transducing, transmitting, and receiving devices. Provide complete report of all system functions upon command. System to be combined with leak detection system specified previously.
- F. Fluid Level Monitor:
1. Digital continuous readout, showing tank oil and water levels in gallons, smallest reading one gallon. Provide identification of product measured, measuring units, and the tank number.
 2. Tank and fuel characteristics contained in programmed non-volatile field-replaceable databases. Protected power supply.
- G. High and Low Fluid Level Alarm System:
1. Automatic continuous on-line monitoring of all tanks.
 2. Visual and audible indicators combined with fluid level monitor. Identify the tank that is in alarm condition.
 3. Manual alarm test and silencing controls.
 4. Low level alarm actuation adjustable 0-25 percent of tank capacity. High level alarm actuation adjustable 75-100 percent of tank capacity.
- H. Locate all indicators, selector switches, alarms on face of wall-mounted panel.
- I. Remote Alarm Annunciator:
1. Visual and audible high level alarms adjacent to tank fill box locations. Locate in NEMA 250 Type 4X weatherproof exterior wall or pole-mounted panels.
 2. Alarm shall include flashing red light with 180 degree visibility for each tank and 95dB horn or 100 mm (4 inch) diameter bell. Provide alarm silence control.
 3. Provide identification sign: "WHEN ALARM SOUNDS - FUEL TANK FILLED TO CAPACITY - DO NOT OVERFILL".
- J. Modbus communication to engineering control system to indicate tank fluid level and alarm conditions. Telephone modem communication capability.

- K. System Performance: Accuracy plus or minus 2.5 mm (0.01 inch) of fluid height in inventory mode and 0.25 mm (0.001 inch) in leak detection mode. Automatic compensation for fluid temperature changes. Volumetric tank tightness sensitivity of 0.4 lph (0.1 gph).
- L. Sensors:
 - 1. Provide sensor types such as magnetostrictive, capacitance, float, hydrostatic and other types as necessary for the applications.
 - 2. Apply in accordance with manufacturer's instructions with provisions for easy future replacement without need for excavation.
 - 3. Provide for each hydrostatic sensor a constant flow differential pressure regulator and pneumatic transmitter protected from fuel contamination. Air supply shall include filter and over-pressure protection. Provide desiccant-type dryer on air supply designed for removal of water vapor. Provide moisture indicator. (Dryer may be deleted if air supply source has a refrigerated dryer.)
 - 4. Float-type units shall be designed for installation and removal through a 3 inch diameter vertical pipe mounted in the top of the tank.
- M. Underground Wiring and Piping: Enclose in water-tight corrosion resistant conduit system sized and arranged as recommended by system manufacturer and conforming to Section 16402, Underground Electrical Construction.
- N. Code Conformance: NFPA-70.
- O. Manufacturer: Veeder-Root Preferred utilities, or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. See section 230100 for installation of oil piping.
- B. Joints: Screwed for pipe two inches and under; ANSI/AWS D1.1, welded, for pipe over two inches.
- C. Provide screened vent elbows for all vent line terminations.

END OF SECTION 230130

SECTION 230140 – NATURAL GAS PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish all labor, material, services and related items necessary to complete the natural gas piping work indicated on the drawings and/or specified herein. Work to be performed shall include, but not be limited to, the following items:
 - 1. Installation of all natural gas piping including connections to all equipment.
 - 2. Connections to the utilities gas meter including all utility service requirements.
- B. Contractor shall arrange with the gas company to extend a natural gas service to the site at the location shown. The cost of this natural gas service shall be included in this contractor's bid. See Civil plans.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation and Seismic Restraints.
- E. Section 230100 - Installation of Piping.
- F. Section 230910 - Start-up, Cleaning and Testing.

1.3 SUBMITTALS

- A. Submit product data for each gas piping, specialty and valve under provisions of Section 230000. Include rated capacities of selected models, furnished specialties and accessories, and installation instructions.
- B. Maintenance data for gas specialties and valves, for inclusion in operating and maintenance manual specified in Section 230000.
- C. Welders' qualification certificates, certifying that welders comply with the quality requirements specified under "Quality Assurance" below.

1.4 QUALITY ASSURANCE

- A. Codes and Standards
 - 1. Applicable local, state and national codes.
 - 2. NFPA Pamphlet 54A and 54
 - 3. Rules and regulations of the local utility company.
 - 4. Service and Line Natural Gas Pressure Regulators ANSI Z21.80.
 - 5. Appliance Natural Gas Pressure Regulators ANSI Z21.18.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Pipe - Carbon steel pipe ASTM-A53 continuous electric weld or seamless, Schedule 40.

- B. Threaded Fittings - Malleable iron, threaded, 150 lb., ASA B16.3, ASA B2.1, material ASTM A-47, Grade 32510.
- C. Weld Fittings - Seamless carbon steel Grade B standard weight butt weld fittings, ASA B16.9, material ASTM A-234.
- D. Unions - Malleable iron, 150 lb., threads ASA B2.1, material ASTM A-47 Grade 32510, ASA B16.3, ground joint, bronze-to-bronze seats.
- E. Flanges - Forged carbon steel bored to match Schedule 40 pipe, 150 lb., ASA B16.5, raised face, slip-on, materials ASTM A-181, Grade 1.
- F. Underground Piping - Material shall be the same as above ground piping with factory applied polyethylene coating. "X-TRU-COAT" by Republic Steel or equal. Joints and any damage to coating shall be repaired with "X-TRU-TAPE" and primer or equal.
- G. Alternate Underground Piping
 - 1. Contractor may use Polyethylene tubing for underground service conforming to ASTM D-2513, SDR-11.
 - 2. Provide an anodeless riser to transition to steel piping above grade for service terminations, Wayne Manufacturing or approved equal. Riser shall have a slip on moisture seal, a stainless steel tracer wire connection and an epoxy coating. Riser shall be pre-bent to 90 degrees and shall have minimum 18 inches cover over horizontal, underground branch pipe.
 - 3. Where polyethylene tubing is used, a 12 gage, yellow tracer wire shall be installed along with the tubing and tubing shall be placed on a 6 inch bed of sand.
 - 4. Provide a 1-1/2" diameter galvanized steel, schedule 40 post with a U-bolt to support the risers at grade. Post shall be 4 feet long and shall be buried 3 feet below grade.

2.2 VALVES AND SPECIALTIES

- A. Gas cocks shall be "Lubroseal" by Mueller Company or approved equal. Use threaded cocks in threaded piping and flanged cocks in welded pipe. Gas cocks shall be bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 125 psig minimum pressure rating. Include feature for locking.
- B. Insulating unions shall be Eclipse Wedge Seal or approved equal. Insulation flanges shall have Type FNDW gasket set as manufactured by F. H. Maloney Company or approved equal. Install unions or flanges where shown on drawings and whether shown or not, at entrance to building.
- C. Mechanically Released Gas Valves 3/4" to 2 inch sizes: A mechanical gas valve, specifically listed by U.L. for use with the kitchen fire suppression system which it is connected, shall be installed for automatic shut off of gas whenever gas appliances are used. The valve shall have a "pull to close" design requiring a pull force to trip a latch which holds the valve in the open position. The cover of the gas valve shall have a visual indicator showing the valve's position.

2.3 GAS PRESSURE REGULATORS

- A. Gas pressure regulators shall be provided for all gas-fired equipment. Equal products by the following manufacturers are acceptable:
 - 1. Maxitrol, Inc.
 - 2. American Meter Co.
 - 3. Actaris Metering Systems
 - 4. Fisher Controls International, Inc.
 - 5. National Meter.
 - 6. Richards Industries, Inc.; Jordan Valve Div.

7. Schlumberger Industries; Gas Div.

B. Gas pressure regulators shall be adjustable, spring compression, single stage and suitable for natural gas fuel service. Include steel jacket, corrosion-resistant components, elevation compensator, and atmospheric vent. Regulators for outside service shall be rated for such use.

1. Natural gas distribution system within the building has been based on a 11 IN. W.C. delivery pressure at the meter.

2. Pipe Connections:

- a. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
- b. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

3. Appliance Pressure Regulators: ANSI Z21.18 with 2 psig inlet pressure rating and outlet pressure of 7 to 11 inches WC. Regulator may include vent limiting device, instead of vent connection, if approved by Authorities Having Jurisdiction. Maxitrol model 325 or equal.

C. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

2.4 FLEXIBLE GAS CONNECTORS

A. Flexible gas connectors shall comply with the following:

1. Bronze metal braided, bellows type, screwed or flanged, unbraided working pressure rating of 45 psig at a maximum service temperature of up to 175F. End fittings factory welded to hose.
2. Suitable for natural gas.
3. Connector length shall be no greater than 24".
4. Manufactured by Flexonics, Anaconda, or Metalflex.

2.5 PRESSURE GAUGES

A. Manufacturer: Subject to compliance with requirements, provide hydronic piping system products from one of the following:

1. Marsh
2. Weiss
3. U.S. Gauge
4. Weksler
5. Trerice

B. Gauges shall be equal to Trerice #800B.

C. Gauges shall include the following:

1. 1-1/2" diameter
2. Drawn steel, black case
3. Styrene acrylonitrile window
4. ABS plastic white dial face with black graduations
5. Bronze tube, Bourdon Type
6. Brass movement
7. 1/4" NPT bottom connections with brass tee handle cock.

D. Submit shop drawings on gauges.

E. Graduation of pressure gauges shall be:

	RANGE	DIVISIONS	FIG. INTERVAL
Gas	0 – 15 psi	0.5 psi	3 psi

- F. Gauge cocks shall be brass, equal to Trerice No. 865 or 880, and shall be provided at all gauges.

PART 3 - EXECUTION

3.1 INSTALLATION – GENERAL

- A. See Section 230100 for general piping installation.
- B. Comply with ANSI Z223.1, "Prevention of Accidental Ignition".
- C. Contractor shall extend gas piping to all gas fired equipment. A gas cock shall be provided at each item.
- D. Gas cocks shall be provided upstream of all gas pressure regulators.
- E. Dirt legs shall be provided at the connection to all gas fired equipment.
- F. Thread sealing compound compatible with service shall be used on all threaded joints.
- G. Gas piping above ground, not in concealed spaces, 3" and smaller shall be either threaded or welded.
- H. Gas piping 3-1/2" and over shall be welded.
- I. All gas piping in concealed spaces shall have joints welded, and pipe shall be run in sealed EMT conduit with both ends vented to the outside of the building. The following gas piping shall be considered concealed:
 - 1. Piping located in walls.
 - 2. Piping located in any non-ventilated space.
- J. Contractor shall extend all gas train vents to and terminate outside the building. Vents shall terminate with screened vent elbow turned down. Each vent connection shall be individually extended to outdoors.
- K. Flexible connectors shall be used only where specifically called for on the plans. Do not install flexible connectors where prohibited by local code.

3.2 PRESSURE REGULATOR INSTALLATION

- A. Install pressure regulators in accordance with manufacturer's written installation instructions.
- B. Regulators installed outdoors shall have a factory furnished vent protector to protect breather hole from rain snow and insects. Or contractor may provide full size pipe and elbows turned down with screened outlet terminated a minimum of 2'-0" above roof or ground.
- C. For vented regulators installed inside the building, extend vent to outside of building or enclosure. Vent pipe shall be turned down, terminated a minimum of 2'-0" above roof or ground with screened vent elbow. Size of vent line shall be not less than 3/4". Where required by regulator manufacturer, increase the size of the vent line to prevent excessive back pressure on the regulator. Where there is more than one regulator at a location, each regulator shall have a separate vent to the outside unless a manifold vent is permitted by the Authorities Having Jurisdiction. Manifolds shall be in accordance with accepted engineering practices to minimize back pressure.

3.3 SERVICE ENTRANCE PIPING

- A. Exterior fuel gas distribution system piping, service pressure regulator and service meter will be provided by gas utility.
- B. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.
- C. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting.

3.4 SERVICE-METER ASSEMBLY INSTALLATION

- A. Coordinate with Gas Utility Company for installation of service-meter assemblies.

3.5 ADJUSTING

- A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 230140

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SECTION 230150 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish all labor, material, services and related items necessary for the refrigerant piping systems shown on the plans and as specified herein. These systems shall include:
 - 1. Refrigerant Piping
 - 2. Refrigerant
 - 3. Refrigerant Piping Specialties
- B. Coordinate refrigerant pipe size with refrigerant component manufacturer.

1.2 RELATED DOCUMENTS

- A. All applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation and Seismic Restraints.

1.3 REFERENCES

- A. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- B. ANSI/ASHRAE 34 - Number Designation of Refrigerants.
- C. ANSI/ASME SEC 8D - Boilers and Pressure Vessels Code, Rules for Construction of Pressure Vessels.
- D. ANSI/ASME SEC 9 - Boilers and Pressure Vessels Code, Welding and Brazing Qualifications.
- E. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- F. ANSI/ASME B31.5 - Refrigeration Piping.
- G. ANSI/ASME B31.9 - Building Services Piping.
- H. AWS - Brazing.
- I. ANSI/ASTM B88 - Seamless Copper Water Tube.
- J. ANSI/AWS A5.8 - Brazing Filler Metal.

1.4 REGULATORY REQUIREMENTS

- A. Conform to ANSI/ASME B31.9.
- B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9 and applicable state labor regulations.
- C. Welder's Certification: In accordance with ANSI/ASME SEC 9.

1.5 SUBMITTALS

- A. Provide submittals in accordance with Section 230000 - Mechanical General Conditions.
- B. Submit shop drawings indicating isometric layout of system, including equipment, critical dimensions, and sizes.
- C. Submit product data indicating general assembly of specialties, including manufacturer's catalog information.
- D. Submit manufacturer's installation instructions under provisions of Section 230000.

- E. Submit welder's certification of compliance with ANSI/ASME SEC 9.
- F. Submit test reports indicating results of leak test, acid test.
- G. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. All refrigerant and refrigerant oil shall be delivered to the site in factory sealed containers.
- B. Deliver and store piping and specialties in shipping containers with labeling in place.
- C. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.

PART 2 - PRODUCTS

2.1 REFRIGERANT PIPE AND FITTINGS

- A. Piping: Copper Tubing, ASTM B280, Type ACR, hard drawn, factory cleaned, dehydrated and pre-charged with nitrogen. "ACR" as manufactured by Mueller Brass Company or equal.
- B. Fittings: ANSI/ASME B16.22 wrought copper or forged brass.
- C. Joints: AWS Classification BAg-1 (silver). Mueller Brass No.122 solder and silver brazing flux or equal. All joints shall be soldered with a constant bleed of nitrogen to prevent formation of oxide or scale.

2.2 REFRIGERANT LINE KITS

- A. Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with refrigerant, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
 - 1. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I, 3/8 inch thick.

2.3 REFRIGERANT SPECIALTIES

- A. Manufacturers: One manufacturer has been listed with the various specialties to establish desired type. Equal product of the following manufacturers are acceptable.
 - 1. Expansion valves, solenoid valves, filter driers, moisture and liquid indicators.
 - a. Alco Valve Company
 - b. Sporlan Company
 - c. Mueller Brass
 - 2. Valves, strainers, check valves, relief valves.
 - a. Mueller Brass
 - b. Henry Valve Company
 - c. Superior Valve Company
 - d. Vilter
 - e. York
 - 3. Receivers
 - a. Standard Refrigeration
 - b. Vilter

- c. E. L. Nickel
- 4. Flexible Connectors
 - a. Resistoflex
 - b. Flexonics
 - c. Keflex
- B. Shut off Valves: Packed, back seating type with seal cap and arranged for straight through flow. Valves shall be full line size with renewable seats, brass body. Capable of being re-packed under line pressure. Rated for maximum working pressure of 500 psi and maximum temperature of 275 degrees F. Mueller Brass "Globemaster".
- C. Filter Driers:
 - 1. Sealed type: "Catch-All" by Sporlan Valve Company. UL listed. Size of drier as recommended by manufacturer with a maximum drop of 1 PSI. Rated for maximum working pressure of 350 psi.
 - 2. Replaceable Cartridge Angle Type: ANSI/ARI 710, UL listed, brass shell and bronze cap, perforated brass shell and molded desiccant filter core; size of drier as recommended by manufacturer with a maximum drop of 1 PSI. Rated for maximum working pressure of 350 psi.
- D. Sight Glasses: Liquid and moisture indicating type, "Eye-Spy" by Alco Valve. Full line size. Where line size is larger than standard sight glass size, install in bypass line using manufacturer's bypass kit in accordance with manufacturer's recommendations.
- E. Solenoid Valves: ARI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, with solder ends; for maximum working pressure of 500 psi. Stem shall permit manual operation in case of coil failure. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with integral junction box; ANSI/UL 429.
- F. Expansion Valves: ARI 750; design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with non-replaceable capillary tube, remote sensing bulb and remote bulb well.
 - 1. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.
- G. Strainers: Brass shell, cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.
- H. Check Valves:
 - 1. Globe Type: Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum working pressure of 500 psi and maximum temperature of 300 degrees F.
 - 2. Straight Thru Type: Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 200 degrees F.
- I. Pressure Relief Valves: Straight Thru or Angle Type: Brass body and disc, neoprene seat, factory sealed and stamped with ASME UV and National Board Certification NB; for standard 235 psi setting; selected to ANSI/ASHRAE 15.
- J. Receivers:

1. Internal Diameter 6 inch and Smaller: ANSI/ARI 495, UL listed, steel, brazed; 400 psi maximum pressure rating, with tappings for inlet, outlet, and pressure relief valve.
 2. Internal Diameter Over 6 inch: ANSI/ARI 495, welded steel, tested and stamped in accordance with Section 8D of the ANSI/ASME Boiler and Pressure Vessels Code; 400 psi with tappings for inlet, outlet and pressure relief valve.
- K. Flexible Connectors: Corrugated stainless steel hose with single layer of stainless steel exterior braiding, minimum 9 inches long with copper tube ends; for maximum working pressure 500 psi.
- L. Refrigerant: R-410A.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Install piping as shown on the plans with no additional bends or offsets. If a conflict occurs between refrigerant piping and other building components, notify the Engineer for resolution before proceeding.
- B. Piping may be pre-insulated line sets if approved by the manufacturer of the condenser, condensing unit, evaporator, and other refrigeration components.
 1. Line sets are not allowed on VRF systems upstream of the branch selector box.
- C. If refrigerant pipe sizes are not shown on the plans, sizing and routing shall be in accordance with the refrigerant component manufacturer's recommendations. If refrigerant pipe sizes are shown on the plans, verify refrigerant pipe sizing and routing with the manufacturer of the condenser, condensing unit, evaporator, and other components PRIOR TO THE INSTALLATION of any piping and report to the Engineer if the sizes or routing are in conflict with the manufacturer's recommendations. Install piping of the sizes recommended by the manufacturer at no additional cost to the Owner or Engineer.
- D. All components of the refrigerant system shall be designed for the type of application, refrigerant, and the system pressures encountered. All components, methods of installation, testing procedures, etc., shall be in accordance with all applicable codes.
- E. Hanging and supporting of refrigerant piping shall be as specified in Section 230100, Installation of Piping.
- F. Pitch piping in the direction of flow with no pockets or traps other than those indicated on the plans. Oil traps that are indicated shall be made as small as possible and still retain the intended function.

3.2 INSTALLATION OF REFRIGERANT SPECIALITIES

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Filter Driers
 1. Provide permanent filter-driers in low temperature systems, systems utilizing hermetic compressors, and where indicated.
 2. Provide replaceable cartridge filter-driers vertically in liquid line adjacent to receivers.
 3. Provide replaceable cartridge filter-driers, with three-valve bypass assembly.
 4. Provide filter-driers for each solenoid valve.
- C. Sight Glasses
 1. Provide sight glasses ahead of all solenoid valves and where indicated.
 2. Provide line size sight glasses in main liquid line leaving condenser, or if receiver is provided, in liquid line leaving receiver.

D. Solenoid Valves

1. Provide solenoid valves in liquid line of systems operating with single pump-out or pump-down compressor control, in liquid line of single or multiple evaporator systems, in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down, and where indicated.
2. Provide electrical connection to solenoid valves.

E. Expansion Valves

1. Provide expansion valves in liquid line at each connection to DX coils (distributor) and where indicated.
2. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
3. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

F. Strainers

1. Provide line size strainer upstream of each automatic valve. Where multiple expansion valves with integral strainers are used install single main liquid line strainer.

G. Shut Off Valves

1. Provide shut-off valves on each side of strainer and where indicated.
2. Provide refrigerant charging (packed angle) valve connections in liquid line between receiver shut-off valve and expansion valve.

H. Check Valves: Install where indicated.

I. Relief Valves: Install where required by code and where indicated.

J. Receivers: Install where indicated.

K. Flexible Connectors

1. Utilize flexible connectors at or near compressors where piping configuration does not absorb vibration and where indicated.
2. Install flexible connectors at right angles to axial movement of compressor.

3.3 TESTING

A. Testing for pre-charged refrigerant line kits is not required.

B. When installation of field installed refrigerant piping and fittings is complete, disconnect and cap all lines to gauges, controllers, etc., which might be damaged by a pressure test. Open all service valves in systems and charge system with refrigerant in accordance with the manufacturer's written requirement. Add sufficient dry nitrogen to raise system to pressures on suction, discharge and liquid sides of system as indicated below (or higher if required by local code). Check all joints and connections for leaks with a halide torch or electronic leak detector. If leaks are found, all leaks shall be repaired and system retested.

C. After system is proven to be completely free of leaks, the entire system shall be dehydrated by evacuating with vacuum pump. System compressors shall not be used as a vacuum pump. Pull system down to 100 microns and hold for 8 hours. Break vacuum with dry nitrogen. Repeat procedure three times with vacuum being broken the last time with refrigerant. Charge system with refrigerant and check the equipment in accordance with manufacturer's recommendations.

D. DO NOT DISCHARGE ANY REFRIGERANT TO THE ATMOSPHERE.

E. Test Pressure Requirements

1. Line Test Pressure for Refrigerant R-410A:
 - a. Suction Lines for Air-Conditioning Applications: 300 psig.
 - b. Suction Lines for Heat-Pump Applications: 535 psig.
 - c. Hot-Gas and Liquid Lines: 535 psig.
- 3.4 Troubleshoot all components of the refrigerant system, both new and existing, when the refrigeration system is started up until the system is operating satisfactorily.

END OF SECTION 230150

SECTION 230200 – MECHANICAL INSULATION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, material and related items necessary to complete the thermal insulation work indicated on the drawings and/or specified herein.
 - 1. Mechanical Piping.
 - 2. Ductwork.

1.2 WORK EXCLUDED

- A. Work not included in this Section that is specified in other Sections of these specifications:
 - 1. Insulation saddles for the piping system - Section 230110.
 - 2. Plumbing systems piping insulation - Section 220400.
 - 3. Duct liner - Section 230900.

1.3 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230100 - Installation of Mechanical Piping.
- D. Section 220400 - Plumbing Systems (plumbing piping insulation).
- E. Section 230900 - Air Distribution.

1.4 QUALITY ASSURANCE

- A. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1.5 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data and installation instructions for each type of mechanical insulation. Submit schedule showing manufacturer's product number, k-value, thickness, and furnished accessories for each mechanical system requiring insulation.
- B. Submit product data under provisions of Section 230000. Indicate application for each product.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.
 - 8. Detail field application for each equipment type.

1.6 DELIVERY, STORAGE, AND, HANDLING

- A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

- B. Store insulation in a clean, dry place and protect against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.

1.7 REFERENCES

- A. ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials.

PART 2 - PRODUCTS

2.1 The piping insulation material for each Type is specified to establish the desired quality and performance. Equal products, complying with the requirements of these specifications, by the following manufacturers are acceptable:

- A. Owens-Corning
- B. Certain-Teed
- C. Armstrong
- D. Manson formerly Manville
- E. Knauf
- F. Rubbatex
- G. Imcoa
- H. Foamglas

2.2 Type (1) - Owens-Corning Fiberglass, Fiberglass 25 with ASJ all service jacket, seal down lap joints, vapor barrier in jacket. Thermal conductivity of 0.26 BTU/HR/SF°F/IN @ 100°F mean temperature, 0.3 @ 200°F, 0.35 @ 300°F. PVC jacket over fittings. Aluminum jacket over straight sections of piping located outdoors.

2.3 Type (2) - Armatuff Plus II (Flame/Smoke Rating less than 25/50 thru 1" thickness per ASTM E-84) Armaflex foamed plastic flexible sheeting laminated with a white thermoplastic rubber membrane (TPR). TPR membrane shall be UV resistant with a 25 year warranty. Thermal conductivity of 0.28 BTU/HR/SF°F /IN @ 90°F mean temperature.

2.4 Type (3) - Armacell AP/Unslit (Flame/Smoke Rating less than 25/50 thru 1" thickness per ASTM E-84) Armaflex foamed plastic flexible tubing insulation Unslit. Thermal conductivity of 0.28 BTU/HR/SF°F /IN @ 90°F mean temperature. See Execution for allowable locations of Lap Seal.

- A. Provide Armafix insulated pipe hangers at all pipe hangers.

2.5 Type (4) - Owens Corning type 703-FRK-25, 3 pound per cubic foot density, rigid insulation. Temperature range -60°F to 450°F. "K" value (BTU/HR/FT^2/IN/F) of 0.28 at 75 degrees F and 0.30 at 100 degrees F. Factory applied vapor barrier. Odor free and resistant to growth of bacteria or fungus.

2.6 Type (5) - Owens Corning type 705-FRK-25, 6 pound per cubic foot density, rigid insulation. Temperature range -60°F to 450°F. "K" value (BTU/HR/FT^2/IN/F) of 0.28 at 75 degrees F and 0.30 at 100 degrees F. Factory applied vapor barrier. Odor free and resistant to growth of bacteria or fungus.

2.7 Type (6) - Owens Corning All-Service Duct Wrap, 1.5 pound per cubic foot density, blanket type insulation with all service facing with a 2" min. stapling and taping flange on one edge. Temperature range -60°F to 250°F. Factory applied reinforced Foil-Kraft (FRK) vapor barrier. Odor free and resistant to growth of bacteria or fungus. Installed thicknesses and R-Values as indicated below. (* hr-ft2-°F/Btu at 75°F mean temperature.) & (** Assumes 25% compression of insulation.)

Nominal			Installed	
Thickness,	Density	Out-of-Package	Thickness,	Installed
in.	pcf	R-Value*	in.	R-Value*

1 ½	.75	5.1	1 1/8	4.2
1 ½	1.0	5.6	1 1/8	4.5
1 ½	1.5	6.1	1 1/8	4.8
2	.75	7.4	1 ½	5.6
2	1.0	7.4	1 ½	6.0
2	1.5	8.2	1 ½	6.4
2 ½	.75	8.5	1 7/8	7.0
3	.75	10.2	2 1/4	8.4

2.8 Type (7) - Hydrous calcium silicate; ANSI/ASTM C533; rigid white; asbestos free; 'k' value of 0.44 at 300 degrees F, 15 pcf maximum dry density, 60 psi minimum compressive strength at 5 percent deformation. Aluminum jacket over straight sections of piping and fiberglass cloth jacket over fittings.

2.9 Type (9) - Polyisocyanurate Board Insulation: ASTM C 1289, Type II, Class 1, Grade 2, felt or glass-fiber mat faced on both major surfaces; maximum board size 48 inches by 96 inches; not less than 2 lbs/cu. ft. density per ASTM D 1622; not less than 20 psi compressive strength; factory-tapered insulation boards fabricated to slopes indicated. Flame Spread: Not greater than 50; ASTM E 84. Smoke Developed: Not greater than 170; ASTM E 84. Tapered Board Insulation: Fabricated to slope of 1/4 inch per 12 inches (1:48) or 1/2 inch per 12 inches (1:24) as noted on the details unless otherwise indicated.

A. Insulation Fasteners: Factory-coated steel fasteners and metal plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening insulation and cover boards to substrates, acceptable to membrane manufacturer.

2.10 Type (10) - Armaflex W (Flame/Smoke Rating 25/50 thru 1" thickness) Armaflex white foamed plastic flexible tubing insulation, unslit. Thermal conductivity of 0.28 BTU/HR/SF°F /IN @ 90°F mean temperature. Available ½" thick thru 2-5/8" ID and ¾" or 1" thick thru 4-1/8" ID.

2.11 Type (12) - Armaflex AP White Unslit (Flame/Smoke Rating 25/50 thru 1" thickness) Armaflex white foamed plastic flexible tubing insulation, Unslit. UV resistant thermal conductivity of 0.28 BTU/HR/SF°F /IN @ 90°F mean temperature. Available ½" thick thru 2-5/8" ID and ¾" or 1" thick thru 4-1/8" ID. See Execution for allowable locations of Lap Seal.

A. Provide Armafix insulated pipe hangers at all pipe hangers.

2.12 JACKETS

A. Vapor Barrier Jackets: Kraft reinforced foil vapor barrier with self-sealing adhesive joints.

B. PVC Jackets: One piece, premolded type.

C. Aluminum Jackets: ASTM B209; 0.032 inch thick; Stucco Embossed corrugated finish; 2-1/2" deep corrugations. Childers jacketing system, ITW Insulation system, or equal.

1. Finish and thickness are indicated in field-applied jacket schedules.

2. Moisture Barrier for Indoor Applications: 1-mil thick, heat-bonded polyethylene and kraft paper or 2.5-mil thick polysurlyn.

3. Moisture Barrier for Outdoor Applications: 2.5-mil thick polysurlyn.

D. Vapor barrier mastic coatings:

1. for outdoor service: Foster Division - 30-15

2. for indoor service: Foster Division - 30-80 or 30-90 (water based)

3. Or equal products by the following manufacturers:

a. Exxon Chemical Company USA

- b. Insul - Coustic IC
 - c. Epolux-Cadalar
- E. Reinforced Polyvinyl-Chloride (PVC) Flashing Sheet: ASTM D 4434, Type III, fabric reinforced and fabric scrim-backed; felt backed; capable of being heat-welded. Sheet Thickness: 60 mils, nominal. (For use on ductwork exterior location where indicated on the plans.)
- F. Thermoplastic Polyolefin (TPO) Flashing Sheet: ASTM D 6878, internally fabric or scrim reinforced, uniform, flexible TPO sheet; free of surface defects and embossing or marking which affect membrane thickness or performance; capable of being heat-welded. Thickness: 60 mils, nominal. (For use on ductwork exterior location where indicated on the plans.)
- G. Removable/Reusable Valve Covers - select one of the following:
1. Cover shall be factory fabricated of 1" close cell elastomeric insulation (Flame/Smoke rating less than 25/50 per ASTM E-84) with Velcro closures. Thermal conductivity of 0.28 BTU/HR/SF°F /IN @ 90°F mean temperature. Cover shall overlap adjoining sections of pipe insulation and shall totally enclose all portions of the valve being covered. Installation shall not require the use of any special hand tools. As manufactured by Corick, Baton Rouge, Louisiana, or approved equal.
 2. Cover shall be factory fabricated of 1-½" fiberglass blanket insulation. Thermal conductivity of 0.26 BTU/HR/SF°F/IN @ 100°F mean. Flame/Smoke rating less than 25/50 per ASTM E-84. Outer jacket shall be made of material equal to DuPont Tychem® QC, overlapping and completely covering the insulation with seams joined with Velcro closures. Butt ends shall have sewn- in-place elastic. Outer jacket shall overlap adjoining sections of pipe insulation and shall totally enclose all portions of the valve being covered. Installation shall not require the use of any special hand tools. As manufactured by "No Sweat" Valve Wraps, Inc., Fit Tight Covers, or approved equal.
 3. Cover shall be factory fabricated with molded polyisocyanurate insulation or molded cellular glass insulation. Polyisocyanurate shall comply with ASTM C591, nominal 2 lb/ft³ density, K factor of 0.19 Btu/hr/ft²F at 75°F mean temperature. Cellular glass shall comply with ASTM C 552, Type III and shall be inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Covers shall comply with Flame/Smoke Rating less than 25/50 per ASTM E-84. Covers shall have close fitting PVC or aluminum jackets. Units shall have plugs that allow valve to be operated without removing the cover. Outer jacket shall have seams joined with Velcro closures, shall overlap adjoining sections of pipe insulation, and shall totally enclose all portions of the valve being covered. Installation shall not require the use of any special hand tools. As manufactured by Extol of Ohio, or approved equal.
- H. PVC Insulation Fitting Covers:
1. Factory fabricated, pre-molded, fitting covers manufactured from 20-mil- thick, high-impact, ultraviolet-resistant PVC.
 2. Factory fabricated, pre-molded, fiberglass fitting inserts, 1-1/2 pound per cubic foot density, semi-rigid insulation formed to fit the pipe fitting, valve, etc. that it is designed to cover.
 3. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, traps, and mechanical joints.
 4. Acceptable manufacturers:
 - a. Ceel-Co, "Ceel-tite #320" (indoors), #330 (outdoors 0 F to 150 F)
 - b. Certain Teed, "Snap Form"
 - c. Foster Div., H.B. Fuller Co., "Speedline Smoke-Safe"
 - d. Knauf, "Proto Lo SMOKE"
 - e. Manville, "Zeston 2000"

5. Adhesive: Compatible with fitting cover material. Do not use regular PVC cement.
 - a. Acceptable manufacturers:
 - 1) Ceel-Co, "Ceel-tite #300" Solvent Welding Adhesive
 - 2) Knauf, "Proto Solvent Adhesive"
 - 3) Manville, "Perma-Weld Adhesive"
 - 4) Aluminum fitting covers by GASCO are equally acceptable.

2.13 ACCESSORIES

- A. Insulation Bands: $\frac{3}{4}$ inch wide; 0.015 inch thick galvanized steel.
- B. Metal Jacket Bands: $\frac{3}{8}$ inch wide; 0.015 inch thick aluminum.
- C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.
- D. Finishing Cement: ASTM C449.
- E. Fibrous Glass Cloth: Untreated; 9 oz/sq yd weight.
- F. Adhesives/Tapes: Compatible with insulation.
- G. Flexible elastomeric foam finish-Armstrong FR/Armaflex finish.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING INSULATION

- A. Install insulation, vapor retarder and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor retarder integrity.
- B. Insulate all pipe, valves, and specialties except where insulation is specifically indicated to be omitted.
- C. All insulation shall be continuous through wall, floor, and ceiling openings and sleeves.
- D. Install insulation with all joints tightly butted (except expansion joints in hot applications).
- E. Piping insulation and jacketing shall be applied in accordance with MICA (Midwest Insulation Contractors Association) Plate #3 (b) requirements. Insulation at hangers shall be applied in accordance with MICA Plate #6A. Insulation for fittings, valves, flanges, and couplings shall be installed in accordance with MICA Plates 10-18.
- F. The open end of all insulation shall be neatly beveled either by beveling the insulation or by using finish cement.
- G. Prior to application of insulation, heat tracing, or painting; piping and equipment shall have been tested and accepted.
- H. All surfaces to be insulated shall be clean and dry. Special solvents are not required for use in cleaning, but any oil, grease, dirt or foreign material shall be wiped or scraped from the pipe or equipment surface. Insulation shall not be applied on damp or frosty surfaces.
- I. All pipe lines with hangers, saddles, etc., shall be set in their permanent location before insulation is applied. Should it be necessary to block or shore up pipe to install insulation, or should it be necessary to displace or remove hangers, the pipe and hangers shall be restored to their original location and alignment when the insulation is complete. Where pipe hangers are installed in a manner that prevents the specified insulation thickness to be installed, the pipe hangers shall be adjusted or moved and rehung to allow the specified insulation thickness to be applied.
- J. Where insulated piping is supported by hangers clamped directly to the pipe, the insulation shall be carefully fitted around hanger clamp and sealed at openings in jacket.

- K. For all cold service piping:
1. Seal the beginning and end of each run of insulation to the pipe being insulated with vapor barrier mastic to prevent air from entering the space between the pipe and the insulation. This especially applies at connections to air handling units and similar equipment. See details on plans.
 2. Install a vapor stop on each side of all valves that are not fully encapsulated by the insulation including all valves where the stem or handle protrudes outside the insulation. The vapor stop shall consist a vapor barrier and mastic to prevent moisture from traveling longitudinally along the insulation in the space between the pipe and the insulation. See details on plans.
 3. Vapor retarder/seal shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor retarder/seal shall be used to attach the vapor retarder/seal or jacketing. No wire ties capable of penetrating the vapor retarder/seal shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
 4. Where cold service piping attaches to coils in air handling equipment, vapor seal the end of the insulation and seal insulation to air handling unit casing. Seal in accordance with air handling unit manufacturer's installation instructions or as directed by the Engineer.
 5. At pipe riser supports, where the support is clamped directly to the pipe, insulation shall be installed over the outside of the riser support clamp and shall totally enclose the riser clamp.
- L. Insulate heating and cooling coil headers located outside of units or ductwork or not located above a condensate pan as specified for piping.
- M. Unions, flanges and valves:
1. All unions, flanges, valves and other similar fittings shall be insulated unless otherwise indicated.
 2. Extended Stems: Where insulation is indicated or specified, coordinate with contractor furnishing valves to furnish extended stems arranged to receive insulation. Cold service valves that are insulated with removable covers do not require extended stems.
 3. For all cold service piping:
 - a. Insulate all fittings, control valves, manual valves (in mechanical rooms and valves exterior to the building), check valves, unions, instruments, hanger rods and clamps, and flanges with molded, pre-shaped insulation inserts of the same material as the straight pipe insulation, or wrap the fitting, valve, etc. with 1.5-pound density flexible fiberglass insulation to a thickness equal to the adjacent piping insulation, and cover with a one piece PVC Fitting Cover per MICA Plate 17A or 18. Tuck the ends of the insulation snugly into the throat of the fitting and the edge adjacent to the pipe fitting. Secure the one piece PVC fitting cover by taping the ends to the adjacent pipe covering. All seam edges of cover shall be sealed with vapor barrier pressure sensitive color matched tape. The tape shall extend over the adjacent pipe insulation and have an overlap on itself at least 2 inches. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
- N. At pipe hangers, furnish and install a sheet metal protection shield and wooden inserts the same thickness as the insulation. Shields and blocks are intended to prevent the crushing of the insulation. Blocks shall be sealed to provide continuity of the vapor barrier.
1. In lieu of the wooden blocks at pipe hangers, this Contractor may, at his option, provide rigid insulation saddle, equal to Fee and Mason Fig. 71, consisting of rigid urethane foam insulation with vapor barrier jacket. Thermal conductivity of 0.13 BTU/HR/FT²/°F/IN @ 75°F. Insulation lengths shall be three (3) times the pipe diameter plus 8" with a minimum length of 20". Insulation thickness shall be the same as the pipe insulation.

O. Exterior Applications

1. Type 3 or 12: Coat with flexible elastomeric foam finish per manufacturer's instructions.

3.2 DUCT INSULATION

A. Installation shall comply with the manufacturer's recommendations using manufacturer's recommended procedures, adhesives, joint tape, and methods.

1. For ducts 18" and larger in width, welding pins shall be used on not greater than 16" o.c. on the bottom and sides of the ducts and maximum 3" from insulation joints to prevent sagging. Pins shall be covered with duct tape. All parts of the duct system shall be insulated in such a manner to form a continuous insulation and prevent excessive heat loss, heat gain, or condensation.
2. For ducts 18" and smaller, place pins along long individual centerline of duct. Space 3" inches maximum from insulation end joints and 16" inch on center.

B. Ductwork Located Outdoors

1. Exterior of ducts shall have rigid board fiberglass insulation secured to the outside with welding pins as described below. All seams shall be butted and taped.
 - a. On horizontal runs, bottom of ducts over 12" wide and/or sides over 16" in height shall be secured with welded pins and speed clips on a maximum of 15" centers.
 - b. On vertical runs, welded pins and speed clips shall be spaced on a maximum of 15" centers on all duct sides over 12".
 - c. Mechanical fasteners shall start within 2" of leading edge of each section, and within 3" of the leading edge of all cross joints within the duct sections. Mechanical fasteners shall be flush with the liner surface.
2. Install an EDPM (Hypalon) waterproof membrane over entire exposed surface. Lap joints a minimum of 6" and seal with manufacturer's recommended double sided tape. Secure jacket to duct with adhesive. See detail on the plans.

3.3 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Ducts and Plenums, Exposed

1. None.

C. Piping, Exposed or Concealed:

1. None.

D. If more than one material is listed, selection from materials listed is Contractor's option.

3.4 PROTECTION AND REPLACEMENT

A. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

3.5 INSULATION THICKNESS

A. The following equipment requires field applied insulation:

1. The following piping requires field applied insulation:

System	Insulation Type	Thickness
Condensate Drain Lines (Inside Building)	3	1/2"
Refrigerant Suction Gas Piping	3	1/2"
Refrigerant liquid piping on any piping lengths over 75ft	3	1/2"
Refrigerant liquid piping (attic)	3	3/4"
Refrigerant liquid piping (exterior)	3 or 12	1"
Refrigerant suction gas piping (exterior)	3 or 12	1"
Reheat supply lines	3	1/2"
Reheat supply lines (exterior and attic)	3	3/4"

2. The following ductwork requires field applied insulation:

System	Insulation Type	Thickness
Rectangular supply and return ductwork located outdoors Jacket with EPDM or TPO flashing.	4	2"
Round supply air ductwork above ceilings, in chases, and other concealed locations	6	1-1/2"
All Outside Air ductwork above ceilings, in chases, and other concealed locations	6	2"

END OF SECTION 230200

SECTION 230605 – ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish all labor, material, services and related items necessary to complete the energy recovery unit installation shown on the plans and as specified herein.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230900 - Air Distribution.
- E. Section 230960 - Temperature Controls.
- F. ANSI/NFPA 70 National Electrical Code.

1.3 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of packaged energy recovery units of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Each unit shall be furnished complete with specified components and accessories as required.
- C. All units shall have energy transfer ratings certified in accordance with ARI Standard 1060, and shall bear the ARI seal.
- D. Units, and all accessories, shall be listed by Underwriter's Laboratories, Inc. or Engineering Testing Laboratories and bear the appropriate U.L. or ETL label.
- E. Where indicated on the plans, units shall have a maximum cross contamination from the exhaust air stream to the make-up air stream of 1.0%. If needed to meet this criteria, unit shall be furnished with a purge section on the wheel.

1.4 SUBMITTALS

- A. Submit shop drawings and product data under provisions of Section 230000.
- B. Product data shall indicate typical catalog of information including optional components and arrangement, unit size, capacities at scheduled conditions, ratings, fan performance, motor electrical characteristics, and gages and finishes of materials.
- C. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- D. Submit manufacturer's installation instructions.
- E. Submit operation and maintenance data under provisions of Section 230000 including start-up instructions, instructions for lubrication, maintenance data, parts lists, controls, and accessories. Include trouble-shooting guide.

1.5 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Latest edition shall apply unless otherwise indicated.

- B. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
- C. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
- D. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials
- E. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- F. ANSI/AMCA Standard 204-05 - "Balance Quality and Vibration Levels for Fans".
- G. ANSI/AHRI Standard 260-12 - "Sound Rating of Ducted Air Moving and Conditioning Equipment".

1.6 STORAGE AND HANDLING

- A. Hoist energy recovery units to the location where they will be installed.
- B. Handle energy recovery units and components carefully to prevent damage, breakage, denting and scoring. Do not install damaged energy recovery units or components; replace with new. Comply with manufacturer's rigging and installation instructions for unloading energy recovery units, and transporting them to final location.
- C. Store in a clean, dry place and protect units from damage by weather, dirt, fumes, construction debris, water, and physical damage.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Construct energy recovery units for exterior or interior installation as indicated. Units shall have supply and exhaust fans, filters for outside air and exhaust air ahead of the energy wheel, an enthalpy recovery wheel (or latent plate type heat exchanger) to transfer both sensible and latent heat between the outside air and exhaust air streams, a single point power connection, motorized dampers on both the outside air intake and the exhaust air outlet, and defrost controls.
- B. Manufacturer shall provide all other components required to provide a complete installation.
- C. Energy recovery unit shall include casing, structural frame, centrifugal fans, V-belt drives and hi-efficiency motors.
- D. All materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with NFPA Standard 84.

2.2 MANUFACTURERS

- A. Energy recovery unit selection has been based on the manufacturer scheduled to establish the desired quality, style and type. Equal products, complying with these specifications by the following manufacturers are acceptable:
 1. Semco
 2. American Aldes
 3. Spinnaker Industries
 4. Aaon
 5. Daikin
 6. Gouvernaire
 7. Greenheck
 8. Valent

2.3 UNIT CABINET: UNITS 3,500 CFM OR LESS

- A. Cabinet shall be constructed of reinforced galvanized steel with minimum 14 gauge frame and minimum 20 gauge skin enclosing minimum 1.0 inch thick, foil faced fiberglass insulation with minimum "R" value ($FT^2 \cdot ^\circ F / BTU / HR$) of 3.5. Unit shall have knockouts for electrical and piping connections, exterior drain connection, and lifting lugs. Unit shall have removable panels for access to the heat wheel. Cabinet shall be finished with either galvanizing or factory-applied corrosion resistant paint. Provide 1/4 turn fasteners at access doors. Cabinet work shall be reinforced and gasketed with neoprene gaskets to withstand the fan close-off static pressure at operating speed. Cabinets shall be suitable for draw-thru arrangement. All metal-to-metal seams shall be sealed, requiring no caulking at job site. Units for outdoor installation shall have top panels joined with a standing seam to insure positive weather protection.
- B. Sheet metal shall be mill-galvanized (two-sided) carbon steel and shall conform to ASTM A525 coating class G-90, lock forming quality.

2.4 ENERGY WHEELS

- A. Enthalpy Wheels
 1. The rotor media shall be made of coated aluminum or lightweight polymer media. All media surfaces shall be coated with a non-migrating solid absorbent layer. Desiccant coatings that are sprayed on or dip coated, or desiccants that must be reapplied over time are not acceptable.
 2. The desiccant shall be for the selective adsorption of water vapor.
 3. Performance and pressure loss data shall be tested in accordance with the ASHRAE 84 standard. The desiccant material shall not transfer pollutants typically encountered in the indoor air environment from the exhaust air to the supply air.
 4. The media shall be cleanable without degrading the latent recovery. Dry particles up to 800 microns shall freely pass through the media.
 5. The rotor shall be supplied with face and perimeter seals.
 6. The rotor housing shall be housed in a removable cassette. The housing shall be made of galvanized steel.
 7. The rotor shall be driven by a self-adjusting belt system and an A/C motor with a variable speed inverter drive.

2.5 FANS

- A. General
 1. Provide fans that are factory fabricated and assembled, factory tested, and factory finished, with indicated capacities and characteristics. Balance fans in accordance with AMCA 204-05.
 2. Fans up to 3,500 cfm shall be DWDI, centrifugal type.
- B. Fans and Shafts: Statically and dynamically balance and designed for continuous operation at the maximum rated fan speed and motor horsepower. Fan shaft shall be turned, ground, and polished steel, designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fan's class.
- C. Belt-Driven Drive assembly: Resiliently mounted to the housing with the following features:
 1. Motor Pulleys: Cast-iron. Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance.
 2. Fan Wheel Pulleys: Cast-iron, fixed pitch.
 3. Dynamically balanced, bored to fit shafts and keyed.

4. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation. Service Factor: 1.5.
 5. Belts: Oil-resistant, non-sparking, and non-static.
- D. Motor and Fan Wheel Pulleys: Adjustable pitch for use with belt driven motors.
- E. Fan Wheels: Hub keyed to the shaft.
1. Blade Materials: Steel or aluminum.
- F. Shaft Bearings: Prelubricated and sealed, self-aligning, ball bearings.
- G. Accessories: The following accessories shall be provided:
1. Adjustable motor slide base.
- H. Isolators:
1. Fans 3,500 cfm or less shall be isolated within the unit on rubber in shear isolators that are seismically restrained. Isolators shall have 0.75" static deflection and be equal to Model RBA by Mason Industries.

2.6 MOTORS AND DRIVES

- A. Motors shall have open, drip proof enclosures and shall have a service factor not less than 1.15. Motors shall be in accordance with Section 230050. Motors shall have electrical characteristics as indicated on the schedule on the plans.

2.7 ACCESS DOORS AND PANELS

- A. Access doors shall be of 20-gage construction and shall provide access from two sides minimum.

2.8 FILTERS

- A. Provide flat filter frames for bottom or side servicing with necessary gasketing to seal between filter and frame and spring type hold down clips to secure filters in place. Air filter shall be 35% efficiency. Filters shall be changeable without the need of tools, nuts or bolts. Size for standard 24" x 24" x 2" filter media. Provide filters for both supply and exhaust airstreams.
- B. Provide 2 inch thick Farr 30-30 filters or equal.

2.9 DAMPERS

- A. Outside air/exhaust air dampers.
1. The dampers shall be equivalent to Ruskin series CD60 low leakage opposed blade control dampers or approved equal.
 2. Frame shall be 16 gauge galvanized steel. Blades shall be 14 gauge equivalent thickness, maximum 6" wide. Seals shall be extruded vinyl blade edge seals and flexible metal compressible jamb seals. Bearings shall be stainless steel sleeve. Axles shall be ½" plated steel hex. Provide mill galvanized finish.
 3. Maximum Leakage at 1" water gauge differential pressure and when tested in accordance with AMCA Standard 500 shall not exceed 4 CFM per sq. ft.
 4. Maximum single dampers section shall be 60" wide x 72" high. For multiple section dampers, each section shall be operated by a separate actuator.
 5. The actuators shall be two position, spring return, normally closed for fail-safe operation, and shall be interlocked to open when the unit is energized. Actuators shall be Belimo or approved equal.

6. The actuator shall have built in overload protection to prevent damage to the actuator when the actuator or damper reaches its end position. The actuator shall be UL listed. Actuator on the fresh air inlet damper shall be provided with auxiliary end switch for fan interlock to be provided under Section 230960.

B. Back draft dampers shall comply with the following:

1. Back draft dampers shall be equivalent to Ruskin model BD-6.
2. Shall have minimum 2", 0.125" thick extruded aluminum frame reinforced for rigidity.
3. Aluminum blades of maximum 6" width.
4. Adjustable counterweight.
5. Cadmium plated steel shafts.
6. Blade shafts shall operate in ball bearings.
7. Hardware shall be cadmium plated steel with brass pins.
8. Dampers shall include blade edge seals. Leakage shall be less than 12 cfm per sq. ft. at 1/2 inch W.G.

2.10 ELECTRICAL

- A. Unit shall have a single connection for the voltage shown on the equipment schedule. Include all starters, transformers, integral door interlock disconnecting device, etc. Include a non-fused disconnect switch at the single point of connection.
- B. Electrical components shall be NEMA 1 enclosures for equipment located indoors and NEMA 3R enclosures for enclosures exposed to the weather.
- C. Starters shall be magnetic type for the motor voltage indicated. In each magnetic starter provide:
 1. Cover-mounted "Start" button, cover-mounted "Hand-Off-Automatic" selector switch or "Start-Stop" pushbutton, and manual overload reset button.
 2. Red "On" pilot light.
 3. Three overload relays properly sized for the actual motor nameplate current and motor operating conditions.
 4. Auxiliary contacts required for sequence of operation.
 5. Control transformer (unless otherwise indicated) for maximum control voltage of 120 VAC complete with primary and secondary overcurrent and short circuit protection.

2.11 MAGNETIC CONTROLLERS

- A. Full voltage, across the line, electrically held, for supply and return fans.
 1. Configuration: Nonreversing.
 2. Contactor Coils: Pressure-encapsulated type
 3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 4. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses.
 5. Solid-State Overload Relay:
 - a. Switch or dial selectable for motor running overload protection.
 - b. Sensors in each phase.
 - c. Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 - d. Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
 - e. Analog communication module.
 6. N.O. isolated overload alarm contact.

7. External overload reset push button.

2.12 CONTROLS

- A. Unit shall be provided with a factory mounted and wired microprocessor control operating on 115 volts or less.
- B. Unit shall have contacts for placing unit in Occupied/Unoccupied operation from a building management time clock.
- C. Wiring in the control panel shall start the exhaust fan, the supply fan, and the energy recovery wheel, after the outside and exhaust dampers are open. Both the supply fan and the exhaust fan shall operate continuously during occupied time periods.
 1. ERU-1 shall run until CO2 sensors on both sides of Training Room and in Soy Display register below 800 ppm.
 2. ERU-2 shall run during occupied time periods per VRF control system.
- D. Unit shall have defrost controls to prevent ice from forming in the unit by stopping the exhaust fan, closing the outdoor damper and circulating return air through both sides of the wheel. Recirculation shall only be required when the outdoor temperature is below 5°F and shall operate no more than 15% of the time.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances, support structure, and other conditions affecting performance of energy recovery units.
- B. Examine rough-in for electrical to verify actual locations of connections prior to installation.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install units level and plumb, in accordance with manufacturer's written instructions. Support units as described below, using the vibration control devices indicated. Vibration control devices are specified in Section 230020 "Vibration Controls."
 1. Support floor-mounted units on concrete equipment bases using vibration isolators as scheduled. Secure units to anchor bolts installed in concrete equipment base. Furnish anchor bolts which are to be inserted in concrete pad to concrete installer.
- B. Arrange installation of units to provide access space around units for service and maintenance.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 sections. The Drawings indicate the general arrangement of piping, valves, fittings, and specialties. The following are specific connection requirements:
 1. Arrange piping installations adjacent to units to allow for unit servicing and maintenance.
 2. Connect piping to units.
 3. Connect condensate drain pans using 1¼ inch copper tubing, unless otherwise indicated. Extend to the nearest equipment or floor drain. Construct trap at connection to drain pan to provide a water seal correlated to the fan TSP and install cleanouts at changes in direction. Install trap per details on the plans and the manufacturer's instructions.

- B. Duct installations and connections are specified in Section 230900. Make final duct connections with flexible connections.
- C. Electrical Connections: The following requirements apply:
 - 1. Electrical power wiring is specified in Division 26.
 - 2. Temperature control wiring and interlock wiring is shall be by Mechanical Contractor.
 - 3. Grounding: Connect unit components to ground in accordance with the National Electrical Code.
- 3.4 Adjust damper linkages for proper damper operation.
- 3.5 Clean unit interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet before start-up and before placing unit in operation.
 - A. Demonstration Services: A contractor's representative shall train Owner's maintenance personnel on the following:
 - 1. Procedures and schedules related to start-up and shut down, troubleshooting, servicing, preventative maintenance, and procurement off replacement parts. A copy of training documentation shall be provided.
 - 2. Schedule training with Owner, provide a least 7 days' advance notice.
 - B. Provide new filters before air balance and before substantial completion.
- 3.6 Refer to Sections 230910, "Start-up, Cleaning and Testing" and 230930 "Balancing" for procedures for air-handling-system testing, adjusting, and balancing.

END OF SECTION 230605

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SECTION 230630 – VENTILATION EQUIPMENT

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, material and related items necessary to complete the exhaust fan installation indicated on the drawings and/or specified herein.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation and Seismic Restraints.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base air ratings on actual site elevations.
- B. Operating Limits: Classify according to AMCA 99.
- C. Vibration Levels: Comply with ANSI/AMCA Standard 204-05, "Balance Quality and Vibration Levels for Fans".
- D. Fan Unit Schedule: The following information is described in an equipment schedule on the Drawings.
 - 1. Fan performance data including capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
 - 2. Fan arrangement including wheel configuration, inlet and discharge configurations, and required accessories.

1.4 QUALITY CONTROL

- A. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA Standard 210 - Laboratory Methods of Testing Fans for Rating.
- B. Sound Power Level Ratings:
 - 1. Comply with AMCA Standard 301 "Method for Calculating Fan Sound Ratings From Laboratory Test Data."
 - 2. Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating."
 - 3. Fans shall be licensed to bear the AMCA Certified Sound Ratings Seal.
- C. UL Compliance:
 - 1. Fans and components shall be UL listed and labeled.
 - 2. Fans shall be designed, manufactured, and tested in accordance with UL 705 "Power Ventilators".
- D. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code".

1.5 SUBMITTALS

- A. General: Submit the following in accordance with Section 230000.
 - 1. Product data for selected models, including accessories.
 - 2. Materials gauges and finishes.
 - 3. Motor ratings and electrical characteristics plus motor accessories.
 - 4. Wiring diagrams that detail power and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.
 - 5. Data for inclusion in Operating and Maintenance Manual specified in Section 230000.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Protect units on site from physical damage.
- C. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

PART 2 - PRODUCTS

2.1 FANS, GENERAL

- A. General: Provide factory fabricated, assembled, tested, and finished fans with indicated capacities and characteristics.
- B. Fans and Shafts: Statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.
- C. Fan Shaft: Turned, ground, and polished steel, keyed to wheel hub, designed to operate at not more than 70 percent of the first critical speed at the top of the speed range of the fan's class.
- D. Belt-Driven Drive assembly: Resiliently mounted to the housing with the following features:
 - 1. Motor Pulleys: Cast-iron. Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance.
 - 2. Fan Wheel Pulleys: Cast-iron, fixed pitch.
 - 3. Dynamically balanced, bored to fit shafts and keyed.
 - 4. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation. Service Factor: 1.5.
 - 5. Belts: Oil-resistant, non-sparking, and non-static.
- E. Shaft Bearings: Provide Type indicated, having a median life "Rating Life" (AFBMA L10) of 200,000, calculated in accordance with AFBMA Standard 9 for ball bearings and AFBMA Standard 11 for roller bearings.
- F. Factory Finish: The following finishes are required for all parts that are not aluminum:
 - 1. Sheet Metal Parts: Prime coating prior to final assembly.
 - 2. Exterior Surfaces: Baked-enamel finish coat after assembly.
- G. Motors: Minimum sizes and electrical characteristics as indicated. If not indicated, motors shall be large enough so that the driven load will not require the motor to operate in the service factor range.
- H. Starters, Electrical Devices, Wiring and connections are specified in Division 26. Disconnect devices are specified below.

- I. Fans used shall not decrease motor size, increase noise level, or increase tip speed by more than 10 percent, or increase inlet air velocity by more than 5 percent, from specified criteria.
- J. Accessories (where indicated on plans):
 - 1. Internally mounted fan speed control rated for 15 amps at 120 vac that can reduce the fan to 60% of the rated airflow.
- K. Fan selections (except vaneaxial fans) have been based on the manufacturer scheduled to establish the desired type, quality, and performance. Equivalent products by the following manufacturers are acceptable:
 - 1. Greenheck Fan and Ventilator Company
 - 2. Loren Cook Company
 - 3. Penn Ventilator
 - 4. Acme
 - 5. Jenn Air
 - 6. New York Blower
 - 7. Twin City

2.2 CEILING MOUNTED AND CABINET FANS

- A. General Description: Centrifugal fan designed for installation in ceiling, wall, or concealed inline applications.
- B. Housing: Galvanized steel lined with 1/2" acoustical liner.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Fan motor shall be mounted on vibration isolators.
- E. Plug-in type disconnect.
- F. Aluminum grille with a white enamel finish.
- G. U.L. listed.
- H. Back draft damper.

2.3 BACKDRAFT DAMPERS

- A. Backdraft dampers shall comply with the following: (except for Utility Vent Sets)
 - 1. General Description: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base or at discharge of wall fan, factory set to close when fan stops.
 - 2. Blades: extruded aluminum, 0.070" thick with extruded vinyl edge seals.
 - 3. Frame: extruded aluminum, 0.125" wall thickness.
 - 4. Linkage: 1/2" tie bars.
 - 5. Bearings: Synthetic.
 - 6. Temperature Range: -40°F to 200°F.
 - 7. Maximum face velocity: 3500 FPM.
 - 8. Maximum Leakage: 12 CFM per square foot at 1/2" W.G. differential.
 - 9. Dampers shall be Ruskin Model BD6 Heavy Duty Backdraft Dampers or approved equal.

2.4 INLINE CENTRIFUGAL FANS

- A. General Description: Belt-driven or direct-drive, as indicated, centrifugal fan consisting of housing, wheel, fan shaft, bearings, motor, drive assembly and accessories.

- B. Housing: Welded steel tubular casing with welded stationary discharge conversion vanes and welded streamlined inlet with conversion vanes to eliminate turbulence.
- C. Internal and external belt guards.
- D. Fan Wheel: Steel hub and steel or aluminum wheel with backward-inclined blades.
- E. Hanging brackets.
- F. Non-fused disconnect switch, factory mounted and wired.
- G. Permanently lubricated pillow block ball bearings. Bearings and drive shall be isolated from air stream.
- H. Fan, drive and motor shall be mounted on a hinged panel which allows entire assembly to swing out for service.
- I. Fan components constructed of steel shall be factory painted with corrosion resistant paint.
- J. Fans shall be suspended on vibration isolators. Isolators shall be furnished with the fan. See Section 230020 for isolator specification.

PART 3 - EXECUTION

- 3.1 Handle Fans carefully to avoid damage to components, enclosures and finish. Do not install damaged components; replace and return damaged components to equipment manufacturer. Store Power Ventilators and Fans in clean dry place and protect from weather and construction traffic.
- 3.2 Install Fans where indicated, in accordance with equipment manufacturer's installation instructions and with recognized industry practices, to ensure that equipment complies with requirements and serves intended purposes. Exhaust fan outlets shall be installed a minimum of 10'-0" away from any outside air intakes for HVAC systems (i.e.: intakes on rooftop units, intake caps or goosenecks, intake louvers, etc.) and any operable windows.
- 3.3 INSTALLATION
 - A. Suspended Units: Fans shall be suspended from structure using threaded steel rods and vibration isolators. Isolators shall be furnished under Section 230020.
- 3.4 Install fans with flexible duct connections. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- 3.5 See Section 230930 for air balancing. Provide replacement fixed sheaves and belts where required for final air balance. Size replacement sheaves to obtain required performance.
- 3.6 FINAL CHECKS BEFORE START-UP
 - A. Remove shipping restraints, blocking, and bracing.
 - B. Verify unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.
 - C. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
 - D. Verify proper motor rotation direction and that fan wheel is free to rotate and bearings operate smoothly.
 - E. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.

- F. Verify manual and automatic volume control dampers in connected ductwork systems are in the full-open position.

END OF SECTION 230630

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SECTION 230680 – ELECTRIC HEATING TERMINALS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, material and related items necessary to complete the electric heating terminal installation indicated on the drawings and/or specified herein.
- B. Extent of electric heating terminal work is indicated by drawings and schedules and as specified herein. Types of units are as follows:
 - 1. Wall Mounted Electric Heaters
 - 2. Electric Baseboard Radiation

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation and Seismic Restraints.
- E. Section 230050 - Motors.
- F. Section 230960 - Temperature Controls.
- G. Refer to Division 26 sections for the following work; not work of this section.
 - 1. Power supply wiring from power source to power connection on terminal unit. Include disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Section 230000.
- B. Product Data: Submit manufacturer's product data indicating typical catalog of information including optional components, color selections & arrangements. Indicate mechanical and electrical service locations and requirements, specifically indicating deviations from indicated products.
- C. Submit manufacturer's installation instructions.
- D. Wiring Diagrams: Submit wiring diagrams for electrical heating terminals showing connections to electrical power feeders, and associated control wiring. Clearly differentiate between wiring which is manufacturer-installed and that which is field-installed.
- E. Data for inclusion in Operating and Maintenance Manual specified in Section 230000.

1.4 QUALITY ASSURANCE

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

1.5 CODES AND STANDARDS

- A. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction, and NEC as applicable to construction and installation of electric heating terminals.
- B. UL Compliance: Provide electric heating terminals which are UL-listed and labeled.

- C. NEMA Compliance: Provide heating terminal accessories which comply with NEMA standards.
- D. NFPA Compliance: Comply with applicable requirements of NFPA 90A and B standards pertaining to construction and installation of duct heating coils.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver electric heating terminals in factory-fabricated type containers or wrappings, which properly protect terminals from damage.
- B. Store electric heating terminals in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, but store above grade and enclose with watertight wrapping.
- C. Handle electric heating terminals carefully to prevent damage, breaking, and scoring of finishes. Do not install damaged units or components; replace with new.

PART 2 - PRODUCTS

2.1 WALL MOUNTED ELECTRIC HEATERS

- A. Manufacturers: See schedule on plans for basis of design selection to establish the desired style and quality. Products by the following manufacturers, complying with these specifications, are acceptable:
 - 1. Brasch Mfg. Co.
 - 2. Q-Mark
 - 3. Berko
 - 4. Markel
 - 5. Indeeco
- B. Fan-forced heater, with fan delay.
- C. Heavy duty steel fins brazed to steel tubular elements in grid pattern which covers entire discharge area.
- D. See plans for Surface or Recessed in standard 2x4 or larger wall sections.
- E. Commercial grade steel grille creates downflow air pattern.
- F. Totally enclosed motor, impedance protected with permanently lubricated bearings.
- G. Built-in snap action thermostat.
- H. Heater and electrical accessories shall be labeled by Underwriters Laboratories, Inc.
- I. Neutral gray baked-on enamel finish.
- J. Furnish optional disconnect switch kit, for electrical to install.
- K. Electrical Power
 - 1. See schedule on plans.
 - 2. Three phase units shall be fed with a 3 wire feeder.

2.2 ELECTRIC BASEBOARD RADIATORS

- A. Manufacturers: selection has been based on Trane to establish the desired style and quality. Products by the following manufacturers, complying with these specifications, are acceptable:
 - 1. Berko Electric Heating; a division of Marley Engineered Products.

2. Chromalox; a division of Emerson Electric Company.
 3. Indeeco.
 4. Markel Products; a division of Marley Engineered Products.
 5. Marley Electric Heating; a division of Marley Engineered Products.
 6. Qmark Electric Heating; a division of Marley Engineered Products.
- B. Assembly: Underwriters Laboratories, Inc. listed and labeled, with thermal box and cover, and built-in controls.
 - C. Heating Elements: Enclosed copper tube, aluminum finned element of coiled nickel-chrome resistance wire centered in tubes and embedded in refractory material.
 - D. Enclosure: Minimum 22 gage steel with 6-3/4 inch high back and top of one piece; front panel, end panel, end caps, corners, and joiner pieces to snap together, and front panel easily removable. Provide full length damper.
 - E. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
 - F. Control: Built-in bi-metal heating thermostat, factory wired or wall mounted electric thermostat.
 - G. Capacity and Voltage: As indicated on drawings.

PART 3 - EXECUTION

- 3.1 Install electric heating terminal units and accessories in accordance with manufacturer's recommendations and with recognized industry practices. Comply with applicable installation requirements of NEC and NECA's "Standard of Installation".
- 3.2 Locate each unit accurately in the position indicated in relation to other work. Position work with sufficient clearance for normal service and maintenance, including clearance for cabinet removal.
- 3.3 Coordinate with the electric contractor for proper power requirements.
- 3.4 Installation of thermostats and other controls by Mechanical Contractor.
- 3.5 Clean dust and debris from each heating terminal as it is installed to ensure cleanliness. Install filters before start and before store opening.
- 3.6 Touch-up scratched or marred heating terminal enclosure surfaces to match original finishes.
- 3.7 Provide equipment grounding connections for electric heating terminals as indicated.
- 3.8 Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std. 486A.
- 3.9 Testing: Upon completion of installation of electric heating terminals, and after building circuitry has been energized, test heating terminals to demonstrate capability and compliance with requirements. Where possible, field correct malfunctioning units, then retest to demonstrate compliance; otherwise, remove and replace with new units and proceed with retesting.

END SECTION 230680

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SECTION 230812 – VRF FAN COIL SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. The system shall be a variable capacity, split system, direct expansion (DX) air conditioning system. The system shall consist of multiple evaporators, refrigerant distribution piping, and a condensing unit and shall use refrigerant R-410A. Heat Recovery systems may connect indoor evaporator capacity up to 130% of the condensing unit capacity. Each evaporator on a heat recovery system shall be capable of operating separately with individual temperature control.
- B. Each system shall include a full charge of refrigerant R-410A and oil.
- C. Performance: The unit selected shall operate at conditions specified in the schedule. The full load operation of the unit shall not exceed the demands indicated on the schedule. System shall provide the efficiency (EER) indicated on the plans or higher.
- D. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with one branch cool/heat selector box. Each indoor unit or group of indoor units shall be able to set its set point via a local controller or an interface with the building DDC system.

1.2 REFERENCES

- A. ANSI Compliance: Comply with ANSI B9.1 safety code requirements pertaining to unit construction of condensing units and condensers.
- B. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- C. ANSI/NFPA 70 National Electrical Code: Comply with applicable National Electrical Code (NEC) requirements pertaining to electrical power and control wiring for construction and installation of condensing units and condensers.
- D. ANSI/UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical.
- E. ANSI/UL 303 - Refrigeration and Air-Conditioning Condensing and Air-Source Heat Pump Equipment.
- F. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
- G. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- H. ARI 520 - Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units.
- I. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units.
- J. ASHRAE Compliance: Construct and install condensing units and condensers in accordance with ASHRAE Std 15-1994, "Safety Code for Mechanical Refrigeration."
- K. ASME Compliance: Construct and test condensing units and condensers in accordance with ASME Boiler and Pressure Vessel Code, Section 8.
- L. UL Compliance: Comply with applicable requirements of UL 465, "Central Cooling Air Conditioners," pertaining to construction and installation of condensing units and condensers. Provide condensing units and condensers which are UL-listed and labeled.

1.3 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions
- C. Section 230010 - Basic Material and Methods.
- D. Section 230020 - Vibration Isolation.
- E. Section 230150 - Refrigerant Piping.
- F. Section 230900 - Ductwork.
- G. Section 230960 - Temperature Controls.

1.4 QUALITY ASSURANCE

- A. The units shall be listed by Electrical Laboratories (ETL) and bear the cETL label.

1.5 SUBMITTALS

- A. Submit shop drawings, product data, and Operation and Maintenance data under provisions of Section 230000.
- B. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- C. Product Data: Submit manufacturer's technical product data, including rated capacities, indicated EERs, weights (shipping, installed, and operating), furnished specialties and accessories; and rigging, installation, and start-up instructions.
- D. Provide templates for anchor bolt placement in concrete pad.
- E. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- F. Operation and Maintenance: Submit manufacturer's operation and maintenance data.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site and hoist in place.
- B. Protect units from physical damage.

1.7 WARRANTY

- A. The units shall have a manufacturer's warranty and a labor warranty for a period of one (1) year from date of substantial completion of the project.
- B. The compressors shall have a warranty of five (5) years from date of substantial completion of the project.

1.8 INSTALLATION REQUIREMENTS

- A. The system shall be installed by a factory trained contractor/dealer. The bidders shall be required to submit training certification proof prior to the start of the installation.
- B. Control wiring shall be installed by a factory trained contractor/dealer with minimum two (2) years' experience installing VRF System Controls.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturer and model numbers given in the schedule are intended to establish desired type, quality and performance.
 - 1. Daikin AC.
 - 2. Sanyo.
 - 3. LG.

- B. For any manufacturer other than scheduled on plans, Mechanical Contractor will be responsible for all changes and costs required to provide an Alternate VRF System including but not limited to:
 - 1. Cost for Architectural, Mechanical, Electrical and Structural revisions as defined in Section 230000, Part 2, "Substitutions", except that the proposal shall not be submitted prior to the bid date.
 - 2. Confirm that proposed manufacturer meets or exceeds heating requirement at zero (0)°F.
 - 3. If alternate unit MCA / MOCP's exceed specified values, include cost of needed electrical feeder and equipment in price of the substitution.

2.2 VRF FAN COIL UNITS

- A. General
 - 1. The following criteria apply to all fan coil units:
 - 2. Casing
 - a. Factory assembled and tested.
 - b. Factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protection, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, fused time delay, and test run switch.
 - c. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
 - d. Provide fresh air intake kit where indicated on the drawings.
 - e. Provide a branch duct knockout for branch ducting supply air where indicated on the drawings.
 - f. Condensate pump shall provide up to 21" of lift unless otherwise noted.
 - g. The condensate pan shall have a built in safety alarm.
 - 3. Controls
 - a. PID control shall be used to control superheat to control the room temperature.
 - b. Return air thermistor.
 - c. The unit shall have controls provided by manufacturer to perform input functions necessary to operate the system.
 - d. A thermistor will be located on the liquid and gas line.
 - e. Provide remote "in-room" wall mounted, hard wired remote sensor.
 - 4. Piping
 - a. Unit and refrigerant pipes shall be charged with dehydrated air prior to shipment.
 - b. Both refrigerant lines shall be insulated.
 - 5. Fan
 - a. The fan shall be direct-drive fan with statically and dynamically balanced impeller with high, medium, and low fan speeds.

- b. The fan motor shall comply with Section 230050, Motors, and operate on the voltage with a motor output indicated on the plans. The fan motor shall be thermally protected.
 - c. The airflow rate shall be as indicated on the plans.
 - 6. Coil
 - a. Coils shall be the direct expansion type constructed from copper tubes expanded into aluminum fins. Capacity shall be as indicated on the plans. The refrigerant connections shall be flare connections.
 - 7. Provide MERV-3 filter.
 - 8. Electrical
 - a. Each fan coil unit shall have a separate power supply at the voltage indicated on the plans.
 - b. Non-fused disconnect switch.
- B. 4 Way Ceiling Cassette Unit
 - 1. Ceiling cassette fan coil unit shall be for installation into the ceiling cavity equipped with an air panel grill for supply and return air.
 - 2. Four-way air distribution type, ivory white, impact resistant, and washable decoration panel. Supply air shall be distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Three auto-swing positions shall be available.
 - 3. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations. Return air shall be through the concentric panel, which shall include a washable, mold resistant filter.
 - 4. The unit's sound pressure shall range from 25 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
 - 5. Schedule on plans shall define 24"x24" versus 30"x30". The 24"x24" units shall fit in a standard 2'x2' grid.
- C. Concealed Ceiling Ducted Unit
 - 1. The unit shall be constructed of a galvanized steel casing with a horizontal discharge air and a horizontal return air or bottom return air configuration as indicated on the plans. Switch box shall be reached from the side or bottom.
 - 2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation and ducted to the supply and return openings.
 - 3. Fan external static pressure shall be as indicated on the plans.
 - 4. Unit height shall be maximum 11-7/8". Condensate drain pump shall lift a minimum of 9-13/16" from the drain pipe opening.
- D. Low Profile Concealed Ceiling Unit
 - 1. The unit shall be constructed of a galvanized steel casing with a horizontal discharge air and a horizontal return air or bottom return air configuration as indicated on the plans. Switch box shall be reached from the side or bottom.
 - 2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation and ducted to the supply and return openings.
 - 3. Fan external static pressure shall be as indicated on the plans.
 - 4. Unit height shall be maximum 7-7/8". Condensate drain pump shall lift a minimum of 9-13/16" from the drain pipe opening.
- E. Wall Mounted Unit

1. Unit shall be a wall mounted fan coil unit for installation onto a wall within a conditioned space.
2. The unit shall have an auto-swing louver which ensures efficient air distribution and closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart.
3. The drain pipe can be fitted to from either left or right sides.

F. Vertical Fan Coil Unit

1. The unit shall be constructed of a galvanized steel casing with an upward vertical discharge air and a bottom return air configuration as indicated on the plans. Switch box shall be reached from the front.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation and ducted to the supply and return openings.
3. Fan external static pressure shall be as indicated on plans.
4. Unit height shall be maximum 5'0". Condensate drain pump shall lift a minimum of 1' 6" from the drain pipe opening.

2.3 OUTDOOR REFRIGERATION UNIT (Condensing Unit)

- A. General: The outdoor refrigeration unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillary tubes at suction lines, subcooling circuits and oil return lines, filters, shut off valves, oil separators, service ports and refrigerant regulator. High/low pressure gas line, liquid and suction lines shall be individually insulated between the outdoor and indoor units.
- B. The maximum connection ratio of indoor units to outdoor unit shall be up to 130%. Each outdoor system shall be able to support the connection of up to the number of indoor units indicated on the plans.
- C. The system shall automatically restart operation after a power failure and shall not cause any settings to be lost.
- D. The unit shall incorporate an auto-charging or an auto-check feature and a refrigerant charge check function.
- E. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
- F. The condenser shall be provided with sub-cooling to prevent flash gas ahead of expansion valves.
- G. Oil recovery cycle shall be automatic.
- H. The outdoor unit shall be capable of starting and heating operation at 0°F dry bulb ambient temperature without additional low ambient controls.
- I. The system shall continue to provide heat to the indoor units in heating operation while in the defrost mode.
- J. The unit shall be constructed from steel panels coated with a baked enamel finish.

- K. The condensing unit shall consist of one or more propeller type, direct-drive fan motors that have multiple speed operation via a digitally commutating inverter. The fan shall be a vertical discharge.
 - L. The fan motors shall have inherent protection and permanently lubricated bearings and be mounted and shall be provided with a fan guard.
 - M. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.
 - N. Scroll compressors shall be variable speed controlled and/or digital scroll type and shall change the speed to follow the variations cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. Monitor evaporator and condenser temperatures control compressor capacity. Digital scroll compressors are acceptable for lead compressors.
 - O. The inverter driven compressor in each condensing unit shall be a hermetically sealed scroll "G-type" with a maximum speed of 7,980 rpm.
 - P. The capacity control range shall be as low as 6%.
 - Q. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
 - R. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector. Compressors shall be spring mounted.
 - S. Provide oil separators together with an oil management system.
 - T. Provide a metal guard over the condenser coils to protect them from hail damage.
 - U. Units sized 6-12 tons shall contain a minimum of 2 compressors, 14 ton units shall contain a minimum of 3 compressors, and 16-20 ton units shall contain a minimum of 4 compressors. In the event of compressor failure the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.
 - V. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or as required by manufacturer for proper operation.
 - W. The power supply to the outdoor unit shall be as indicated on the plans.
 - X. The control wiring shall be a shielded or non-shielded as required by equipment manufacturer.
- 2.4 BRANCH SELECTOR BOX
- A. Galvanized steel selector boxes shall be factory assembled, wired, and piped and shall be run tested at the factory
 - B. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling expansion valve.
 - C. Each cabinet shall house multiple refrigeration control valves and a liquid gas separator, shall contain a tube in tube heat exchanger, and have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.
 - D. The unit shall be furnished with a electronic expansion valves to control the direction of refrigerant flow. Refrigerant connections shall be brazed.

- E. Multiple indoor units may be connected to a branch selector box with the use of a REFNET™ joint provided they are within the capacity range of the branch selector.

2.5 SYSTEM CONTROLS

- A. VRF system controls shall be web accessible for adjusting and viewing all FCU's, setpoints, and schedule.

PART 3 - EXECUTION

- 3.1 Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances, housekeeping pads, and other conditions affecting performance of fan coil units. Do not proceed until unsatisfactory conditions have been corrected.
- 3.2 Install fan coil units level and plumb, in accordance with manufacturer's written instructions.
- 3.3 Provide isolators and seismic restraints in accordance with Section 230020.
- 3.4 Arrange installation of fan coil units to provide access space around units for service and maintenance.
- 3.5 Refrigerant Piping
 - A. Install refrigerant piping of the sizes shown on the drawing in accordance with manufacturer's recommendations and Section 230150.
 - 1. Refrigerant line sets may be used for refrigerant lines up to and including 5/8 inch diameter, but not upstream of branch selector boxes.
 - 2. Hard drawn ACR copper piping shall be used for any lines larger than 5/8 inch.
 - 3. See Section 230150, Refrigerant Piping, for tolerances on refrigerant piping slope and level.
 - B. Charge per manufacturers specifications with R-410A. Do NOT discharge any refrigerant to the atmosphere.
 - C. Insulate ALL refrigerant piping; both gas and liquid lines. Coat all insulation exposed to sunlight. See Section 230200, Mechanical Insulation.
- 3.6 Duct installations and connections are specified in other Section 230900, Ductwork. Make final duct connections with flexible connections.
- 3.7 Connect condensate drain line and route to floor drain or as otherwise indicated on the plans.
- 3.8 Electrical Connections: The following requirements apply:
 - A. Electrical power wiring is specified in Division 26.
 - B. Temperature control wiring and interlock wiring is by Mechanical Contractor.
 - C. Grounding: Connect unit components to ground in accordance with the National Electrical Code.
- 3.9 Clean unit cabinet interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheel and cabinet.
- 3.10 Refer to Sections 230910, "Start-up, Cleaning and Testing", 230930 "Testing and Balancing" for additional requirements.

END OF SECTION 230812

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SECTION 230850 – FURNACES AND MATCHING CONDENSING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, material and related items necessary to complete the Furnace and Condensing Unit installation indicated on the drawings and/or specified herein.
- B. Furnaces and condensing units shall be by the same manufacturer unless otherwise indicated.

1.2 REFERENCES

- A. ANSI/NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
- B. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
- C. ANSI/NFPA 70 National Electrical Code.
- D. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
- E. ANSI/UL 207 - Refrigerant-Containing Components and Accessories, Non-Electrical.
- F. ANSI/UL 303 - Refrigeration and Air-Conditioning Condensing, and Air-Source Heat Pump Equipment.
- G. ANSI/UL 465 - Central Cooling Air Conditioners.
- H. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- I. ARI 520 - Positive Displacement Refrigerant Compressors, Compressor Units and Condensing Units.

1.3 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Mechanical Materials and Methods.
- D. Section 230020 - Vibration Isolation.
- E. Section 230050 - Motors.
- F. Section 230130 - Fuel Oil Piping.
- G. Section 230140 - Natural Gas Piping.
- H. Section 230150 - Refrigerant Piping.
- I. Section 230890 - Breechings, Chimneys, and Stacks
- J. Section 230900 - Ductwork.

1.4 QUALITY ASSURANCE

- A. All units shall be rated and certified as complete units in accordance with ARI Standard 210/240-94 and shall bear the ARI seal. Cooling capacity ratings shall be based on ARI Standard 340/360-93 requirements.
- B. Units, and all accessories, shall be listed by Underwriter's Laboratories, Inc. and bear the appropriate UL label.

1.5 SUBMITTALS

- A. Submit product data under provisions of Section 230000.
- B. Indicate electrical service and duct connections on product data.
- C. Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing in close out documents.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver products to site and hoist in place.

- B. Protect units from physical damage.

1.7 WARRANTY

- A. Entire unit shall have a one year warranty as described in section 230000.
- B. The compressor shall be warranted an additional four (4) years beyond the first year. The additional four years for the compressor shall be for parts only and shall not include labor.

PART 2 - PRODUCTS

2.1 FURNACE

- A. Selection has been based on the manufacturer scheduled to establish the desired type, performance and quality. Equal products, complying with these specifications, by the following manufacturers are equally acceptable:
 - 1. Carrier
 - 2. Daikin
 - 3. Trane
 - 4. Johnson Controls
- B. Gas furnaces shall include and/or comply with the following:
 - 1. Unit shall be a factory fabricated, assembled and tested unit, and shall include all safety and operating controls, wiring, piping, etc. necessary for proper operation.
 - 2. Upflow, AGA certified natural gas fired furnace.
 - 3. Direct vent sealed combustion system with side wall terminations for combustion air and vent pipes.
 - 4. Pilotless ignition system.
 - 5. Annual Fuel Utilization Efficiency (AFUE) rating of 93% minimum.
 - 6. Heat exchanger designed for condensation of flue gases. With a 20 year warranty.
 - 7. Control transformer.
 - 8. Heating-cooling programmable setback thermostat with battery back-up, digital clock and manual override.
 - 9. Multiple speed fan motor with cooling relay.
 - 10. Copper tube, aluminum fin evaporator coil assembly with galvanized drain pan and drain connection. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.
 - 11. Twinning kit for units indicated on the plans to allow two furnaces to operate as a single unit.
 - 12. Provide CPVC condensate drain piping to connect furnace condensate trap to cooling coil drain line.
 - 13. Provide flue exhaust piping and intake piping per Section 230890.
- C. Oil Furnaces shall include and/or comply with the following:
 - 1. Unit shall be factory fabricated, assembled and tested unit, and shall include all safety and operating controls, wiring, piping, etc. Necessary for proper operation.
 - 2. Upflow, CSA certified oil furnace.
 - 3. Direct vent sealed combustion system with side wall or roof terminations for combustion air and vent pipes. Sealed combustion system must be approved by oil burner manufacturer.
 - 4. Oil burners shall be by Beckett, Riello or equivalent. Annual Fuel Utilization Efficiency (AFUE) rating of 83% minimum.
 - 5. Combustion chamber / heat exchanger shall be composed of stainless and aluminized steel with welded seams.
 - 6. Cabinet shall be made of 22-gauge painted steel with insulated walls for quiet operation.

7. Control transformer.
8. Heating-cooling programmable setback thermostat with battery back-up, digital clock and manual override.
9. Variable speed fan motor.
10. Twinning kit for units indicated on the plans to allow two furnaces to operate as a single unit.
11. Provide CPVC condensate drain piping to connect furnace condensate drain piping to connect furnace condensate trap to cooling coil drain line.
12. Provide flue exhaust piping and intake piping per Section 230890.

D. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace. Include condensate drain pan with accessible drain outlet complying with ASHRAE 62.1.

1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
2. Configuration: Up feed with bottom suction to prevent trapping of oil.

E. Cooling Coil Drain Pans:

1. Provide 20 gage galvanized steel drain pan for cooling coils with soldered corners or cold galvanized coating on corners. Minimum 3 inches deep; extend 3 inches from face of coil entering air side and 6 inches from face of coil leaving air; extend on sides of coil bank to 1 inch beyond the greatest projection of coil headers and tube return.
2. Slope pan to the drain connection at minimum 1/8" per foot in direction of airflow. Accommodation for deflection of pan and pan supports shall be made to prevent condensate from standing in drain pans.
3. Provide one 1-1/2" drain pipe connection.
4. Insulate exterior of drain pan with 3/4" thick closed cell rubber to prevent condensation.

F. Miscellaneous Features

1. Filters - Provide 2" Throwaway Filters. Provide access from side panel for removal. Filter rack shall be field converted to two inch capability with field provided filters.
2. Thermostats: Provide 24 volt operation control, factory-supplied and field-installed. Heating-cooling programmable setback thermostat with battery back-up, digital clock and manual override. Provide number of heating and cooling steps indicated or required to match condensing unit. Include system selector switch automatic changeover and fan control switch (auto-on).
3. Vibration Isolators: Provide neoprene floor-mounted isolators to reduce transmission of noise and vibration to building structures.

2.2 AIR COOLED CONDENSING UNIT

A. Selection has been based on the manufacturer scheduled to establish the desired type, performance and quality. Equal products, complying with these specifications, by the following manufacturers are equally acceptable:

1. Carrier
2. Daikin
3. Trane
4. York

B. Air cooled condensing unit shall include and/or comply with the following:

1. Unit shall be a factory fabricated, assembled and tested unit, and shall include all safety and operating controls, wiring, piping, etc., assembled in such a manner that the only

field connections required are refrigerant suction, refrigerant liquid, electrical power, and control connections.

2. Casing shall make unit fully weatherproof for outdoor installation. Casing shall be fabricated from galvanized steel and shall have a factory applied baked enamel finish. All edges of the metal shall have the same finish to protect the material from rusting. Openings shall be provided for power and refrigerant connections. Panels shall be removable to provide access for servicing.
3. Condenser coil shall be fabricated from copper tubes with mechanically bonded aluminum fins. Coil shall be circuited for subcooling.
4. Condenser fans shall be direct driven propeller type. Each fan shall have a fan guard. Fan motors shall have inherent protection, shall be resiliently mounted, and shall have permanently lubricated bearings.
5. Refrigerant system shall include a filter drier, suction and liquid line service valves with pressure taps and charging connections.
6. Compressors shall comply with the following:
 - a. Shall be the hermetic type.
 - b. Internal and external vibration isolators.
 - c. Compressor shall include a crankcase heater.
 - d. Compressor shall include discharge and suction shutoff valves.
7. Condensing unit shall include the following controls:
 - a. High head pressure cutout.
 - b. Low suction pressure cutout.
 - c. Timer to prevent short cycling of compressors.
 - d. Condenser fan controls.
8. Condensing units, where indicated on the plans, shall include the following options:
 - a. Head pressure controls suitable to allow operation down to 0°F.
 - b. Winter start controls to allow compressor start to 0°F ambient.
 - c. Liquid line solenoid valve.
9. Condensing unit shall comply with the following standards:
 - a. Ratings shall be in compliance with ARI 520.
 - b. ANSI/ASHRAE 15 Safety Code.
 - c. Wiring shall comply with the National Electrical Code.
 - d. Unit shall be ETL or UL listed.
10. Unit wiring shall include:
 - a. Field power connection, control interlock terminals and unit control system shall be located in a weatherproof enclosure. Panel access doors shall key lock. Dead-front panels shall be provided on the line voltage side.
 - b. Control circuit transformer and fusing.
 - c. Positive acting timer to prevent short cycling of compressor (approx. 5 minutes).
11. Condensing unit shall have condenser fans with a vertical discharge.
12. Condenser Coil Hail guard.
13. Condensing unit shall have a minimum SEER rating of 13.

PART 3 - EXECUTION

3.1 INSTALLATION OF FURNACE

- A. Install units, where indicated on drawings, in accordance with manufacturer's published installation instructions, with recommended clearances provided for service and maintenance.
- B. Support units as described below, using the vibration control devices indicated.
 - 1. Support floor-mounted units on floor using vibration isolators as scheduled. Secure units to floor to meet seismic Provide sufficient height for trap installation and proper drainage.
 - 2. Suspended Units: Units shall be suspended from structure using threaded steel rods, double nuts with lockwashers, and vibration isolators. Provide sway bracing in accordance with requirements of section 230020.
- C. Connect ductwork with a flexible connector and connect condensate drain line. Route condensate drain to floor drain.
- D. Provide secondary drain pan under the unit per details on the plans.
- E. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- F. Replace filters with new filters before air balance for any units that have been operated during construction.
- G. Install intake and exhaust piping to sealed combustion chamber.
- H. Connect natural gas or fuel oil piping, ductwork and condensate drain line. Route Install drain piping from the sealed combustion chamber to a sanitary drain.
- I. Install drain piping from the sealed combustion chamber to a sanitary drain. Provide a JJM Boiler Works, JM series, condensate neutralization tube in the line between the furnace and the sanitary drain.
- J. Mounting for the furnace shall be able to withstand 50 lb lateral force.

3.2 INSTALLATION OF CONDENSING UNITS

- A. Install units, where indicated on drawings, in accordance with manufacturer's published installation instructions, with recommended clearances provided for service and maintenance.
- B. Condensing units shall be located on concrete pad provided by this contractor.

3.3 REFRIGERANT PIPING

- A. Install refrigerant piping of the sizes shown on the drawing in accordance with manufacturer's recommendations and Section 230150.
- B. Charge per manufacturers specifications with R-410a or Puron. Do NOT discharge any refrigerant to the atmosphere.
- C. Insulate suction piping. Paint all insulation exposed to sunlight.

3.4 ELECTRICAL CONNECTIONS: THE FOLLOWING REQUIREMENTS APPLY:

- A. Electrical power wiring is specified in Division 26.
- B. Temperature control wiring and interlock wiring is by Mechanical Contractor.

END OF SECTION 230850

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SECTION 230890 – BREECHINGS, CHIMNEY AND STACKS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, material and related items necessary to complete the HVAC heating system installation indicated on the drawings and/or specified herein.
- B. Extent of work required by this section is indicated on schedules, and by requirements of this section.

1.2 SECTION INCLUDES

- A. Manufactured chimneys for gas fired equipment.
- B. Breechings.
- C. Combustion air intakes for gas fired equipment.

1.3 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Mechanical Basic Materials and Methods.
- D. Section 230020 - Vibration Isolation.

1.4 REFERENCES

- A. ANSI/ASTM A525 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot- Dip Process, General Requirements.
- B. ANSI Z21.66 - Electrically Operated Automatic Vent Damper Devices for Use with Gas-Fired Appliances.
- C. ANSI Z223.1 (NFPA 54) - The National Fuel Gas Code.
- D. ASHRAE - Handbook, Equipment Volume, Chapter "Chimney, Gas, Vent, and Fireplace Systems."
- E. ASTM A527 - Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality.
- F. ASTM D 1784 - Chlorinated PolyVinyl Chloride (CPVC) Pipe and Fittings
- G. ASTM D 1785 - Poly Vinyl Chloride Plastic Pipe, Schedules 40, 80, and 120
- H. ASTM D 2665 - PolyVinyl Chloride (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
- I. ASTM D 2855/ ASTM D 2564 - Plastic Solvent Cement for PVC Plastic Pipe
- J. ASTM F 438 - Socket-Type Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe Fittings, Schedule 40
- K. ASTM F 441 - Chlorinated PolyVinyl Chloride (CPVC) Plastic Pipe, Schedules 40 and 80
- L. ASTM F 493 - Plastic Solvent Cement for CPVC Plastic Pipe.

- M. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel- Burning Appliances.
- N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- O. UL 103 - Standard for Factory Built Low Heat Chimneys.
- P. UL 378 - Standard for Draft Equipment.
- Q. UL 441 - Standard for Gas Vents.
- R. UL 641 - Standard for Low Temperature Venting Systems.

1.5 DEFINITIONS

- A. Breeching: Vent Connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.
- D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.6 Design Requirements: Factory built vents and chimneys used for venting natural draft appliances shall comply with NFPA 211 and be UL listed and labeled.

1.7 SUBMITTALS

- A. Submit shop drawings, product data, and manufacturer's installation instructions data under provisions of Section 230000.
- B. Submit shop drawings indicating general construction, dimensions, weights, support and layout of breechings. Where factory built units are used submit layout Drawings indicating plan view and elevations.
- C. Submit product data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights.

1.8 Conform to applicable code for installation of natural gas burning appliances and equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Selkirk Metalbestos
- B. American Metal Products
- C. Barron
- D. Schebler

2.2 TYPE B DOUBLE WALL GAS VENTS

- A. Fabricate inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, tested in compliance with UL 441.
- B. Description: Double wall gas vents, UL listed for Type B, consisting of an inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, with the following minimum thicknesses:

Size	Inner Pipe	Outer Pipe
Round, up to 6"	0.0012"	28 gauge
Round, 7" to 18"	0.0014"	28 gauge
Round, 20" to 24"	0.0018"	26 gauge
Oval, up to 4"	0.0012"	28 gauge
Oval, 5" to 6"	0.0014"	28 gauge

- C. Accessories: UL labeled tees, elbows, increasers, draft hood connectors, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, clean-outs, fire stop spacers, and fasteners, fabricated of similar materials and designs as vent pipe straight sections.
1. Install electrically actuated vent dampers that are provided with the boiler in compliance with ANSI Z21.66.

2.3 VENT CONNECTOR

- A. Fabricate of ASTM A569 carbon steel. Fabricate connectors of ASTM A527 galvanized sheet steel, lock forming quality with ANSI/ASTM A525 G90 zinc coating.
- B. Fabricate connectors and fittings from following minimum gages. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible.
1. Sizes up to 9 inches: 24 gauge.
 2. Sizes 10 inches to 16 inches: 22 gauge.
 3. Sizes over 16 inches: 16 gauge.
- C. Provide adjustable self-actuating barometric draft dampers, where indicated, full size of breeching.
- D. Provide cleanout doors of same gage as breeching, where indicated on Drawings.
- E. For connectors less than 24 inches diameter provide groove seam (pipe lock or flat lock) with end joints beaded and crimped.
- F. Fabricate connector fittings to match adjoining connectors. Fabricate elbows with center-line radius equal to connector width. Limit angular tapers to 20 degrees maximum.

2.4 POSITIVE PRESSURE STACK

- A. Provide a factory built modular connector, manifold and stack system for stacks located on the discharge side of flue fans.
- B. Stacks shall be laboratory test and listed by Underwriters laboratories for use with building heating equipment which produce exhausted flue gases at a temperature not exceeding 1,000 degrees F. under continuous operating conditions and not exceeding 1,400 degrees F under intermittent operating conditions in accordance with NFPA 211.
- C. The system shall be designed and installed to be gas tight and prevent leakage into a building. The system shall compensate for all flue gas induced thermal expansion. Provide manufacturer recommended accessories such as guying supports.
- D. The stack wall shall be double wall construction with an inner pipe of 304 stainless steel and an outer wall of aluminum coated steel. The nominal space between the walls shall be one (1) inch.
- E. The inner pipe joints shall be sealed with factory supplied V bands and sealant approved by the manufacturer.

- F. Roof penetrations shall be provided with a storm collar for non-combustible roof construction and with a ventilated thimble for combustible roof construction.
- G. Include the following accessories as needed: U.L. labeled tees, elbows, increasers, metal cap with bird barrier, adjustable roof flashing, storm collar, support assembly, thimbles, clean-outs, fire stop spacers, and fasteners. Fabricate of similar materials and design as vent pipe straight sections.
- H. Stack shall be Metalbestos Model PS or approved equal.

2.5 BREECHING

- A. Breeching shall be constructed from 10 gauge carbon steel with all joints continuously welded.
- B. Sections shall be joined by either continuous welds or by bolted flanged joints. Flanged joints shall be gasketed and sealed gas tight using heat resistant gaskets.
- C. Breeching shall be insulated with Code (2) insulation. See specification section titled "Thermal Insulation".
- D. Completed installation shall comply with NFPA 211.

2.6 FLUE FOR HIGH EFFICIENCY WATER HEATERS AND FURNACES

- A. Provide a factory built modular connector, manifold and stack system for flues from high efficiency, condensing type water heaters and furnaces and ANSI Category I, II, III, or IV appliances and Direct Vented appliances. UL 1738/ULC S636 listed with continuously welded seams to meet all code requirements for condensing and positive pressure special gas vent systems. Double wall construction with 430 stainless steel outer jacket and superferritic stainless steel, type AL 29-4C®®, for components in contact with flue gases. Temperature up to 550°F. Pressure up to 15" wc. Natural gas or propane fuel units.
- B. Completely engineered from the appliance flue outlet to the termination: starters elbows, boot-tees, drain fittings, and supports. Sizes 6" - 32" with tapered male and female ends, Ring-and-Tab tapered closure system that prevents penetration of the flue-gas conduit by any lower alloy, non-approved fasteners. Seal with factory-supplied sealant.
- C. Flue shall be Saf-T Vent CI Plus by Heatfab, Inc. or approved equal.

2.7 INTAKE FOR HIGH EFFICIENCY WATER HEATER AND BOILERS

- A. Poly-vinyl Chloride Pipe and Fittings: (except not allowed in ceiling plenums)
 1. PVC schedule 40 pipe with plain ends: ASTM D-2665.
 2. Socket fittings, schedule 40: ASTM D-2665.
 3. Solvent cement joints: ASTM D-2665.
- B. Chlorinated Poly-vinyl Chloride Pipe and Fittings:(for use in ceiling plenums)
 1. CPVC schedule 40 pipe with plain ends and fittings: Spears Lab Waste CPVC complying with ASTM D-1784 and ULC listed as equal to ASTM E-84 having a flame spread rating of less than 25 and a smoke developed rating of less than 50.
 2. Solvent cement: ASTM F-493.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions and UL listing.

- B. Install in accordance with recommendations of ASHRAE - Handbook, Equipment Volume, Chapter "Chimney, Gas, Vent, and Fireplace Systems," and ANSI Z223.1 (NFPA 54).
- C. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA HVAC Duct Construction Standards - Metal and Flexible for equivalent duct support configuration and size. Provide seismic supports requirements for the seismic zone listed in section 230000.
- D. Pitch vent connectors with positive slope of 1/4" per foot up from fuel-fired equipment to chimney or stack.
- E. For Type B double wall gas vents and Positive Pressure Stack, maintain UL listed minimum clearances from combustibles. Assemble pipe and accessories as required for complete installation.
- F. Install vent dampers, locating close to draft hood collar, and secured to breeching.
- G. Level and plumb chimney and stacks.
- H. Clean connectors, breechings, chimneys, and stacks during installation, removing dust and debris.
- I. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of connectors, breechings, chimneys, or stacks.
- J. Provide minimum length of breeching or connector to connect appliance to chimney. Provide Type B chimney continuously from appliances.
- K. Coordinate opening in roof for installation of stack with roofer. Provide flashing.
- L. Seal vent connector, where indicated or where connector will be under positive pressure, with 550 deg. F silicone sealant approved for the application by the appliance manufacturer. Seal all transverse and longitudinal points.
- M. For PVC and CPVC intakes and vents, install Spears LabWaste CPVC where pipes pass through plenum rated ceilings.
- N. All air intakes shall be insulated with 2" fiberglass insulation. See section 230200.

3.2 CHIMNEY / STACK SCHEDULE

<u>EQUIPMENT</u>	<u>CHIMNEY / STACK</u>
Oil Furnace (non-condensing)	Type B
Gas Furnace (high eff./condensing)	Saf-T Vent CI Plus
Oil Furnace (with Power Ventilator)	Positive Pressure Stack
Water Heater (with Power Ventilator)	Positive Pressure Stack

3.3 Combustion Air Intake Schedule

<u>EQUIPMENT</u>	<u>COMBUTION AIR INTAKE</u>
Gas Furnace (high eff./condensing)	PVC pipe or CPVC pipe for ceiling plenums
Oil Furnace (with Power Ventilator)	PVC pipe or CPVC pipe for ceiling plenums
Water Heater (with Power Ventilator)	PVC pipe or CPVC pipe for ceiling plenums

END OF SECTION 230890

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SECTION 230900 – AIR DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section includes rectangular and round metal ducts and plenums for heating, ventilating, and air conditioning systems in pressure classes from minus 2 inches to plus 10 inches water gauge.
- B. Furnish all labor, services, material and related items necessary to complete the ductwork installation indicated on the drawings and specified herein.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Basic Materials and Methods.
- D. Section 230020 - Vibration Isolation.
- E. Section 230200 - Mechanical Insulation - external duct insulation.
- F. Section 230930 - Testing and Balancing.
- G. Section 230960 - Temperature Controls - motorized dampers.
- H. Section 260720 or 260721, Fire Alarm System - Smoke Detectors.

1.3 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Latest edition shall apply unless otherwise indicated.
- B. AMCA 500 - Test Method and Louvers, Dampers and Shutters.
- C. ASTM A 36 - Carbon Structural Steel.
- D. ASTM A 167 - Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip.
- E. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality.
- F. ASTM A 480 - General Requirements for Flat-Rolled Stainless Steel, Sheet and Strip.
- G. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
- H. ASTM A 527 - Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality.
- I. ASTM A 568 - Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled.
- J. ASTM A 569 - Steel, Carbon (0.15 Maximum, Percent), Hot-Rolled Sheet and Strip, Commercial Quality.
- K. ASTM B 209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- L. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- M. AWS D9.1 - Welding of Sheet Metal.
- N. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
- O. NFPA 96 - Installing of Equipment for the Removal of Smoke and Grease-Laden Vapors from Commercial Cooking Equipment.
- P. SMACNA -HVAC Air Duct Leakage Test Manual, 1st Edition.
- Q. SMACNA - HVAC Duct Construction Standards - Metal and Flexible. (2005 Third Edition) (subsequently referenced as "SMACNA 2005").
- R. UL 33 - Standard for Safety Heat Responsive Links for Fire Protection Service.
- S. UL 181 - Standard for Safety Factory-Made Air Ducts and Connectors.

- T. UL 555 - Standard for Fire Dampers.
- U. UL 555S - Standard for Safety Leakage Rated Dampers for Use in Smoke Control Systems.
- V. UL 2043 - Fire test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Section 230000.
- B. Product data including materials, details of construction, dimensions of individual components, profiles, manufacturer's installation instructions, and finishes for the following items:
 - 1. Air Devices: Submit schedule of outlets and inlets indicating type, size, accessories, finish/color, type of mounting, air performance, static pressure drop, throw, and noise level.
 - 2. Duct Liner
 - 3. Sealant and Gasket Materials
 - 4. Fire-Stopping Materials
 - 5. Flexible ducts and clamps, with manufacturer's installation instructions
 - 6. Flexible Connectors
 - 7. Backdraft Dampers
 - 8. Balance Dampers
 - 9. Access Doors
 - 10. Louvers
- C. Ductwork Reinforcement Information: Submit information on the duct reinforcement to be used for each section of duct. Information shall include copies of tables from SMACNA construction standards highlighting the actual duct sizes, pressure class, material, gauge, reinforcement type and spacing, joint type and spacing, applied loads, and hanger type and spacing. When alternate methods of sizing are used as provided by SMACNA, provide calculations to support the reinforcement selection.
- D. Proposed deviations of materials and methods from these specifications require approved submittal information prior to any construction. Submittals should clearly note that the submittals is for a change to the specifications and identify the applicable paragraph from this specification. Submittals shall include physical descriptions and results of testing and analysis to support the equal performance of the substituted items. Testing and analysis shall follow the guidelines for "Functional Criteria" from SMACNA standards.
- E. Record drawings indicating duct actual routing in accordance with Section 230000.
- F. Duct leakage testing confirming compliance with tests required for ducts over 2 inches WG pressure class.

1.5 QUALITY ASSURANCE

- A. Perform Work in accordance with SMACNA 2005 - HVAC Duct Construction Standards - Metal and Flexible.
- B. Manufacturer Qualifications: Company specializing in manufacturing Products specified with minimum 5 years documented experience.
- C. Installer Qualifications: Company specializing in performing the Work of this Section with minimum 5 years documented experience.
- D. Regulatory Requirements: Construct ductwork to NFPA 90A and NFPA 96 standards.
- E. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests:
 - 1. All ducts over 2 inches WG pressure class shall meet requirements of seal class A in Section 1 of SMACNA HVAC Air Duct Leakage Test Manual.

2. All ducts 2 inches w.g. pressure class or less shall meet requirements of seal class C.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Section 016000 - Product Requirements: Transport, handle, store, and protect Products.
- B. Protect dampers from damage to operating linkages and blades.
- C. Deliver sealant and fire-stopping materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- D. Store and handle sealant and fire-stopping materials in compliance with manufacturer's recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

1.7 Sheet metal work as shown on plans is schematic and is based on the specified manufacturer's equipment and material dimensions. Contractor shall make accurate measurements in the field prior to duct work fabrication and shall provide all necessary offsets and transition pieces required to accommodate actual structural and equipment variations.

1.8 The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing to the Engineer.

1.9 At contractor's option, round duct may be substituted for rectangular construction and vice versa (except in exposed areas). Equivalent round duct sizes shall be in accordance with ASHRAE Fundamentals 2009, chapter 21, Table 2. Contractor shall be responsible for coordination with other trades and any subsequent costs incurred by others for substituting round and rectangular ductwork.

1.10 Rectangular duct dimensions are sheet metal dimensions. For those ducts with internal liner, the duct dimensions include the liner.

1.11 Round duct dimensions are inside, free area dimensions.

1.12 The work shall be coordinated with that of other trades in such a manner that when the installation is complete, all items are properly installed and are serviceable.

1.13 Static Pressure Classifications: Except where otherwise indicated, construct duct systems to the following pressure classifications:

- A. Supply Ducts for non VAV systems: 2 inches water gauge.
- B. Supply Ducts between supply fan and VAV boxes: 4 inches water gauge.
- C. Supply Ducts downstream of VAV boxes: 2 inches water gauge.
- D. Return and Relief Ducts: 2 inch water gauge, negative pressure.
- E. Outside Air Ducts: 2 inch water gauge, negative pressure.
- F. Supply Ducts from Energy Recovery Units: 2 inch water gauge, positive or negative pressure.
- G. Exhaust Ducts on Suction Side of an Exhaust Fan: 2 inches water gauge, negative pressure.
- H. Exhaust Ducts on Discharge of an Exhaust Fan to building exterior: 2 inch water gauge.
- I. Exhaust Ducts upstream of exhaust VAV boxes: 4 inches water gauge.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Supply, return, outside air, and relief air ductwork for HVAC systems, Exhaust ductwork (except where otherwise indicated below), and Supply ductwork to kitchen hood systems shall be constructed of:

1. Galvanized Sheet Steel, Lock-forming quality, Coating Designation G 90.
2. Provide mill phosphatized finish for ducts exposed to view that are to be painted.
3. Reinforcement, Support, Hanger, and Trapeze Shapes and Plates:
 - a. ASTM A 36/A 36M, steel plates, shapes, and bars. Unless otherwise indicated, provide galvanized finish of fabricated plates, shapes, and bars or provide fabricated plates, shapes, and bars of the same material as the sheet metal ducts.
 - b. Strut-Channels: Duct reinforcements, supports, and trapeze hangers may alternatively be a bolted metal framing system equal to B-Line. The system shall be channels, fittings and hardware as defined and tested in accordance with the Metal Framing Manufacturers Association Standard Publication MFMA.
 - 1) Channels shall be epoxy coated and made from steel meeting ASTM A570, Grade 33. Hot dip galvanizing after fabrication shall be in accordance with ASTM A123.
 - c. Where the galvanic index of the reinforcements, supports, hangers, or trapeze and the duct materials is greater than 0.15 volts (galvanized-steel plates, shapes, bars, or struts are used to reinforce aluminum or stainless steel ducts), isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

B. All materials used shall meet the requirements of NFPA 90A and UL 181 for Class I air ductwork.

C. Minimum Sheet Metal Gauges for Ductwork:

1. Rectangular ductwork shall be fabricated from the following minimum thicknesses, regardless of duct construction methods, for sizes indicated:

<u>Max. Long Side Dimension</u>	<u>Steel Gauge</u>
0-12 inches	26
13-30 inches	24
31-54 inches	22
55-84 inches	20
85 inches and above	18

2. Round ductwork shall be fabricated from the following minimum gauges for sizes indicated: (Round ductwork shall not be allowed for ducts over 84".)

<u>Max. Long Side Dimension</u>	<u>Steel Gauge</u>
2-12 inches	26
13-21 inches	24
22-35 inches	22
36-49 inches	20
50-59 inches	18
60-84 inches	16

3. Minimum gauges for stainless steel shall be the same as listed for steel.
4. Minimum thickness and reinforcement for aluminum shall be as indicated in SMACNA 2005 Table 2-50, 2-51 and 2-52 for rectangular - ducts and 3-14, 2-51, and 2-52 for round ducts.

D. Sealants:

1. Joint and Seam Sealant: 3M-900 sealer.
2. Flanged Joint Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer. Rated per ASTM E-84 with maximum flame spread and smoke developed

ratings of 10. Ductmate 5511M for attaching flanges to ducts, Ductmate 440 tape for flange to flange joints, or approved equal.

3. Isolation Gaskets: Butyl rubber, neoprene, silicone rubber, or EPDM polymer with polyisobutylene plasticizer. Rated per ASTM E-84 with maximum flame spread and smoke developed ratings of 10.
4. Slip On Flange Joint Mastic: Non-drying, non-skinning, polymer base, pumpable sealant. ASTM E-84 with maximum flame spread and smoke developed ratings of 5. Ductmate 5511M for attaching slip on flanges to ducts or approved equal.
5. Fire-Resistant Sealants for filling openings around duct penetrations through walls and floors shall be as specified in Section 230010, Basic Mechanical Materials and Methods.
6. General Sealant: One-part, acid-curing, Silicone, elastomeric joint sealant, complying with ASTM C 920, Type S (single component), Grade NS (nonsag), Class 25, Use O. Provide one of the following:
 - a. Chem-Calk 1200; Bostik Inc.
 - b. 999-A; Dow Corning.
 - c. Construction 1200 or Contractors SCS1000 or SCS1702F; GE Silicones.
 - d. HiFlex 392 or NuFlex 302; NUCO Industries, Inc.
 - e. HM 270; Ohio Sealants, Inc.
 - f. 860 or 863; Pecora Corporation.
 - g. Tremsil 300; Tremco.

E. Acoustical Joint Sealants:

1. Applications: Seal joints in drywall sound enclosures as indicated on the sound enclosure details.
2. Acoustical Sealant for Exposed and Concealed Joints: Provide manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. Product shall effectively reduce airborne sound transmission through perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90. Products: Provide one of the following:
 - a. AC-20 FTR Acoustical and Insulation Sealant; Pecora Corporation.
 - b. BA-98; Pecora Corporation.
3. Acoustical Sealant for Concealed Joints: For each product of this description indicated in the Acoustical Joint-Sealant Schedule at the end of Part 3, provide manufacturer's standard, nondrying, nonhardening, nonskinning, nonstaining, gunnable, synthetic-rubber sealant recommended for sealing interior concealed joints to reduce airborne sound transmission. Provide one of the following:
 - a. SHEETROCK Acoustical Sealant; USG Corp., United States Gypsum Co.
 - b. Pro-Series SC-170 Rubber Base Sound Sealant; Ohio Sealants, Inc.
 - c. Tremco Acoustical Sealant; Tremco.

2.2 SINGLE WALL RECTANGULAR DUCT FABRICATION

- A. Fabricate rectangular ducts in accordance with SMACNA 2005 Tables 2-1 through 2-48, including their associated details, and the Model Specifications shown in SMACNA 2005, except where this specification requires otherwise. Conform to the requirements in the referenced standard for metal thickness (except comply with minimum gages show above), reinforcing types and intervals, tie rod applications, and joint types and intervals.
- B. All reinforcements between transverse joints for duct dimension greater than 36 inches shall extend past the edge of the duct and be secured with an approved tie rod or tie angle as generally shown in SMACNA 2005 Figure 2-12 for "tie alternatives for two side reinforcements".

- C. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.
- D. Where Ductmate (or equal) joints are used, they shall be rated as reinforcing class "F" for Ductmate 25, reinforcing class "G" for Ductmate 35, or reinforcing class "H" for Ductmate 45 and integrated with the requirements of SMACNA Tables 2-1 through 2-28. Similar tables from Ductmate Industries shall not be substituted for the SMACNA 2005 tables. Ductmate joints shall be installed in compliance with the manufacturer's recommendations.
- E. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
- F. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20 gauge or less, with more than 10 sq. ft. of unbraced panel area, as indicated in SMACNA 2005 Figure 2-9, unless they are lined or are externally insulated.
- G. Tie Rods:
 - 1. Internal tie rods shall be allowed for ducts 36" wide and wider. Midpanel tie rods shall be allowed for ducts 36" wide through 96" wide.
 - a. Internal tie rods and midpanel ties shall not be allowed:
 - 1) Within 20 feet of a fan discharge or fan inlet.
 - 2) In kitchen hood exhaust ducts.
 - 3) In Fume exhaust ducts.
 - 4) In underground, in-slab, or under slab ducts.
 - 5) In fittings with non-parallel sides unless they have load distributing means such as wedges.
 - 6) In ducts with duct liner.
 - 7) For oval ducts, aluminum ducts or polyvinyl coated steel ducts, unless otherwise noted on the drawings.
 - 2. The maximum internal tie rod diameter shall be 3/4"; straps used for tie rods shall be maximum 1/8" thick and shall be installed with the thickness facing the air flow; angles or other structural shapes shall not be used for internal tie rods. Tie rods shall be attached to ducts in accordance with SMACNA 2005, Figures 2-5 and 2-6.
 - 3. Threaded inserts placed in pipes, tubes and conduits shall be secure for 200% of the loads indicated in SMACNA 2005, Table 2-34.
 - 4. Where internal ties occur in two directions, they shall be either prevented from contacting or be permanently fastened together.
- H. Singular Wall Rectangular Duct Fittings:
 - 1. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA 2005 Figures 4-1 through 4-9 and 7-1 through 7-4.
 - 2. All rectangular duct elbows shall be radiused in accordance with SMACNA Figure 4.2 type RE-1 (centerline radius equal to 1.5 x W) unless otherwise indicated.
 - a. Other Fitting Types:
 - 1) Provide radius elbows with vanes, Figure 4.2 Type RE-3, where indicated and in accordance with details shown; minimum inner radius shall be equal to 0.5 x W unless otherwise shown; two (2) or three (3) internal vanes shall be provided as indicated on the drawings per Figure 4-9 and spaced per Chart 4-1.

- 2) Rectangular square throat duct elbows shall be provided only where indicated.

2.3 SINGLE WALL ROUND DUCT FABRICATION

- A. Round ductwork shall be spiral lockseam construction as detailed in Fig. 3-1 of SMACNA 2005, unless otherwise indicated, and shall comply with minimum gauges indicated above and be reinforced per SMACNA 2005 Tables 3-5 through 3-13 for the pressure ratings indicated.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Lindab Inc.
 2. McGill AirFlow LLC.
 3. SEMCO Incorporated.
 4. an approved local fabricator.
- C. Except where interrupted by fittings, provide round ducts in lengths not less than 12 feet.
- D. Transverse joints shall be beaded sleeve joints (type RT-1) as detailed in Fig. 3-1 of SMACNA 2005; vanstone flanges (type RT-2); welded, companion angle flanges (type RT-2A); or slip on flanges.
 1. Type RT-1 joints shall be secured with sheet metal screws as described in Fig. 3-1. Seal with joint and seam sealant.
 2. Type RT-2 joints (vanstone angles) shall have a minimum 3/8" flange on the duct with a continuous, rolled, back up angle. Provide a 3/16" thick Flanged Joint Gasket between the flanges.
 3. Type RT-2A joints (companion angle) shall have a continuous weld at the end juncture of the duct and the flange and shall have tack welds on 8" centers at the back leg of the angle flange. Provide a 3/16" thick Flanged Joint Gasket between the flanges.
 4. Slip on flanges shall be Ductmate Econoflange, Semco Accuflange, or approved equal and shall only be used with their ratings. Provide a 3/16" thick Flanged Joint Gasket between the flanges and apply Slip on Flange Joint Mastic.
- E. Attach reinforcing angles as detailed in Fig. 3-1-RT-2A of SMACNA 2005. Reinforcing rings and companion flange joints shall be as indicated in Tables 3-2, 3-3, and 3-4.
- F. Branch connections shall be made with 90° conical and 45° straight taps as shown on the drawings. All branch connections for new ducts shall be made as a separate fitting; saddle taps may be used for fittings that are added to existing ducts.
 1. Where saddle taps are installed on existing ducts, the opening in the main duct shall closely match the saddle tap inlet opening. The entrance to the saddle tap shall have no excess material projecting into branch tap entrance. No burrs or rough welds will be allowed.
 2. The saddle tap shall be attached to the main duct with welds or screws on 3" centers maximum and the joint shall be sealed.
- G. Runouts to Air Devices:
 1. In lieu of spiral lockseam construction, runouts may be fabricated with snaplock longitudinal joints (type RL-8) as detailed in Fig. 3-1 of SMACNA 2005. Transverse joints shall be either beaded sleeve joints (type RT-1) or crimp joints (type RT-5) as detailed in Fig. 3-1 and secured with sheet metal screws as indicated in the SMACNA details.
 2. Elbows for Runouts to Air Devices: Adjustable (Gored) Elbows may be used for supply ducts only at maximum 2 inch pressure class, minimum 4 piece construction, and maximum 18" diameter.
 3. Seal all joints. Fabricate with minimum 24 gauge galvanized steel.

H. Round Duct Fitting Fabrication:

1. Ductwork and fittings shall be by the same manufacturer.
2. Circumferential and longitudinal seams of all fittings shall be a continuous weld or spot welded and sealed with mastic. All welds shall be painted to prevent corrosion.
3. 90-degree Tees and Laterals and Conical Tees: Fabricate to conform to SMACNA 2005 Figures 3-5 and 3-6 and with metal thicknesses specified for longitudinal seam straight duct. Where bullhead tees are provided, they shall be Semco type BHT, BHT-1R, or BHT-2R with turning vanes or approved equal.
4. Diverging-Flow Fittings: Fabricate with entrance to branch taps with no excess material projecting from the body onto branch tap entrance. No burrs or rough welds will be allowed.
5. Elbows: Fabricate with die-formed, pleated, segmented (welded) or adjustable gore construction. Fabricate the bend radius of die-formed, segmented and pleated elbows 1.5 times the elbow diameter. Fabricate the bend radius of adjustable gore elbows 1.0 times the elbow diameter. Unless elbow construction type is indicated, provide elbows meeting the following requirements.

a. Segmented Elbows:

- 1) Fabricate mitered elbows with continuous welded construction in gauges specified below.
- 2) Elbows Radius and Number of Pieces: Unless otherwise indicated, construct elbow to comply with SMACNA 2005 Table 3-1.
- 3) Elbows - Gauges: Provide minimum metal thickness listed below for pressure classes shown:

Pressure Class Range Size	-2 to 2"	2" to 10"
3 to 14 inches	24 gauge	24 gauge
15 to 26 inches	24 gauge	22 gauge
27 to 36 inches	22 gauge	20 gauge
37 to 50 inches	20 gauge	20 gauge
52 to 60 inches	18 gauge	18 gauge
62 to 84 inches	16 gauge	16 gauge

- b. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems, or exhaust systems for material handling classes A and B; and only where space restrictions do not permit the use of 1.5 bend radius elbows. Fabricate with single-thickness turning vanes. Equal to Semco model 902V. Elbows shall have a minimum number of vanes in accordance with the following:

Duct Diameter	Number of Vanes
3" thru 9"	2
10" thru 20"	3
21" and up	5

- c. For supply duct runouts to air devices only at maximum 2 inch pressure class, 24 gauge galvanized steel, Adjustable (Gored) Elbows with minimum 4 piece construction, and maximum 18" diameter may be used. Seal all joints.

- d. For Pressure Class above 2 inch.

- 1) Round Elbows - 8 Inches and smaller shall be die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend angle configurations or 1/2-inch-diameter (e.g. 3½ and 4½ inch) elbows with segmented construction. Die-Formed Elbows shall be 20 gauge with 2-piece continuous welded construction. Pleated Elbows shall be 26 gauge.

- 2) Round Elbows - 9 Through 14 Inches shall be segmented or pleated elbows for 30, 45, 60, and 90 degrees, except where space restrictions require a 2 piece mitered elbow. Fabricate nonstandard bend angle configurations or ½ inch-diameter (e.g. 9½ and 10½ inch) elbows with gored construction. Pleated Elbows shall be 26 gauge. Segmented elbows shall be as indicated in the next paragraph.
 - 3) Round Elbows - 9 inches and Larger shall be segmented elbows with continuous welded construction, except where space restrictions require a 2 piece mitered elbow.
6. Couplings: Slip-joint construction per SMACNA 2005 Figure 3-2, detail RT-1 with a minimum of a 2-inch insertion length.
 7. PVC-Coated Elbows and Fittings: Fabricate elbows and fittings as follows:
 - a. Round Elbows 4 to 8 Inches in Diameter: Two piece, die stamped, with longitudinal seams spot welded, bonded, and painted with a PVC aerosol spray.
 - b. Round Elbows 9 to 26 Inches in Diameter: Standing seam construction.
 - c. Round Elbows 28 to 60 Inches in Diameter: Standard gore construction riveted and bonded.
 - d. Other Fittings: Riveted and bonded joints.
 - e. Couplings: Slip-joint construction with a minimum 2-inch insertion length.

2.4 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder actuated fasteners, or structural steel fasteners appropriate for building materials and local authority having jurisdiction.
 1. Powder actuated fasteners shall not be allowed where the piping, ductwork or equipment is required to meet seismic bracing requirements in Section 230020 or the Building Code and unless the powder actuated fasteners are rated for these seismic loads. Powder actuated fasteners shall not be allowed in tension applications for Seismic Design Category D, E or F (as defined by the International Building Code).
 2. Do not use powder actuated concrete fasteners unless approved by the Engineer in writing.
- B. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58 and MSS SP-69 except as modified herein.
- C. Upper attachments shall be as indicated in SMACNA 2005 Figures 5-1 through 5-4.
 1. C-Clamps: Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.
 2. Structural Attachments shall be B-Line, Unistrut, Grinnel, or approved equal:

Beam clamps:	B 3031, B 3033, B 3034, B 3050, B 3045
Angle Iron Beam Clamp:	B 3046
Bar Joist:	B 3059
Concrete Inserts:	B 3500, B 2505 thru 2508, or B 3014
Drilled Inserts:	Phillips Red-head, wedge anchors or equal.
- D. Hangers:
 1. Strap and band hangers shall be fabricated of the same material as the sheet metal ducts.
 2. Hanger sizes shall be as indicated in SMACNA 2005 Tables 5-1 and 5-2 for sheet steel width and gauge and steel rod diameters.
 3. Rod hangers shall be fabricated of round, cadmium-plated threaded steel rods and nuts.

- a. Rod hangers Installed in Corrosive Atmospheres: Electro-galvanized, all-thread rod or hot-dipped-galvanized rods with threads painted after installation.
 - b. Hanger rods shall be threaded both ends, threaded one end, or continuously threaded.
4. Seismic sway bracing shall be in accordance with Section 230020.
- a. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
 - b. Steel Cables for Stainless-Steel or Aluminum Ducts: Stainless steel complying with ASTM A 492.
 - c. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Lower Attachments:
- 1. Duct attachments shall be sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
 - 2. Lower attachment shall be as indicated in SMACNA 2005 Figure 5-5.
- F. Trapeze and Riser Supports:
- 1. Trapeze sizes shall be as indicated in SMACNA 2005 Tables 5-3 and 5-4 and Figure 5-6 and 5-8 through 5-10.
 - 2. Where trapeze or riser supports are a different material than the sheet metal duct, a minimum 1/16 inch thick isolation gasket shall be provided between the duct and the support.

2.5 FLEXIBLE ROUND DUCT

- A. Low Pressure Flexible duct shall be UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire coated to prevent corrosion; fiberglass insulation; and fiberglass reinforced aluminized vapor-barrier film and shall be used for systems up to 2" static pressure class.
- 1. Insulated, Flexible Duct: round duct shall be Thermaflex M-KM or by Flexmaster, Flexible Technologies, ATCO, or Quietflex.
 - 2. Factory installed insulation shall be min. 3/4 pound density 1-1/2" thick, minimum R-4.2.
 - 3. Exterior vapor barrier shall have maximum vapor barrier permeance of 0.05 perm per ASTM Method E96, Procedure A
 - 4. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
 - 5. Rated Air Velocity (or higher): 4000 fpm.
 - 6. Temperature Range: Minus 20 to plus 175 deg F.

2.6 FLEXIBLE CONNECTORS

- A. Flexible connectors installed inside the building shall be heavy glass fabric, double coated with neoprene, of approximately 30 oz. per square yard, provided with 3" wide, 24 ga. metal mounting strips firmly attached to each edge. Connectors shall be suitable for pressure class of the air handling system. Flexible connectors shall be "Ventfab" by Ventfabrics, Inc. or equal.
- B. Flexible connectors installed outside the building shall be heavy glass fabric, double coated with neoprene, of approximately 26 oz. per square yard, provided with 3" wide, 24 ga. metal mounting strips firmly attached to each edge. Connectors shall be suitable for pressure class of the air handling system. Flexible connectors shall Ventlong Hypalon by Ventfabrics, Inc. or equal.

2.7 FLEXIBLE ELBOW SUPPORT

- A. Shall meet UL 2043.
- B. Approved manufactures are:
 - 1. Flex Flow Elbow by Thermaflex
 - 2. Flex Right Elbow by Titus.

2.8 DUCT LINER

- A. Fiber Glass Duct Liner shall comply with ASTM C 1071, NAIMA AH124, "Fibrous Glass Duct Liner Standard, and NFPA Standard 90A.
- B. Materials: ASTM C 1071, Type I, with an anti-microbial, coated surface exposed to airstream to prevent erosion of glass fibers.
- C. Thickness & Density: See Shop Application of Liner in Rectangular Ducts under Part 3 below.

Normal		
Thickness,	Density	
in.	pcf	R-Value*
1/2	1.5	2.2
1	1.5	4.2
1-1/2	1.5	6.0
2	1.5	8.0
1-1/2	3.0	6.5
2	3.0	8.7

- D. Thermal Performance: Provide minimum "R-Value" indicated above, at a mean temperature of 75°F.
- E. Liner, including coatings and adhesives shall have a flame spread of 25 or less and a smoke developed rating of 50 or less as determined in accordance with ASTM Standard E84.
- F. Liner Adhesive shall be a water-based adhesive complying with NFPA 90A or NFPA 90B and with ASTM C 916. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24). Operational temperature range -20 to +160°F; curing time 24 hours. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
 - 1. Adhesive shall be Benjamin Foster 85-60, United McGill, type Uni-Tack or approved equal.
- G. All exposed edges and the leading edge of all cross joints of the liner shall be sealed to prevent glass fibers from separating and entering the airstream. Sealer shall be Benjamin Foster 30-36 or approved equal.
- H. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct. Provide fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50-pound tensile dead load test perpendicular to the duct wall.
 - 1. Fastener Pin Length: As required for thickness of insulation, and without projecting more than 1/8 inch into the airstream.
 - 2. Adhesive for Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.
- I. The duct liner shall have a surface roughness that gives an Air Friction Correction Factor not greater than 1.2 at velocities of 4000 FPM.

J. The liner shall have the following Noise Reduction Coefficients Frequency:

Frequency	Coefficient
125	.23
250	.54
500	.68

K. The duct liner shall Owens Fiberglass Quiet R Rotary Duct Board or equal by Knauff, Manville, Certain Teed or equal.

2.9 External Duct Insulation: See Section 230200 - Mechanical Insulation.

2.10 AIR DEVICES

A. Model numbers for air devices are given in the Air Device Schedule. The model numbers and manufacturers listed are given to establish the desired style, quality, and performance. Products by the following manufacturers, equal to those scheduled and complying with these specifications, are equally acceptable.

1. Titus
2. Krueger
3. Nailor
4. Price
5. Tuttle & Bailey
6. Metal Aire

B. Diffuser and return air grille sizes given on the plans are neck sizes. Grille sizes are core sizes.

C. Air devices shall have an NC rating of NC30 or less at specified CFM.

D. Air devices shall be sized to match the ceiling grid. Furnish air devices for either regular grid ceilings or for narrow grid ceilings or for both types of grid; coordinate with the architectural reflected ceiling plans.

E. Air device finishes shall be as follows:

1. Ceiling mounted - Flat White
2. Wall mounted - Flat White, verify with Architect
3. Floor mounted - Shall be coordinated with Architect
4. Duct mounted - Light grey prime coat on steel materials and natural non-oxidizing finish on aluminum
5. Opposed blade dampers - Black
6. Other as called for in the Schedule

F. A sponge rubber gasket shall be provided on back side edge of all mounting frames to provide a snug tight fit to construction surfaces.

G. Where round ductwork is used, provide a square-to- round adapter with the air device.

H. Slot diffusers shall comply with the following:

1. Diffuser shall include a factory fabricated plenum of minimum 26 gauge galvanized steel.
2. Inside of plenum shall be internally insulated with 1/2" duct liner. Liner shall meet specifications for duct liner indicated above.
 - a. Portions of plenum not factory insulated shall be externally insulated with 1 1/2", 1lb duct wrap per specification 230200.(specifically end caps)
3. Plenum shall include an inlet collar for flexible round duct. Inlet shall include a balance damper.

- I. Linear Bar diffusers shall comply with the following:
 1. Diffuser shall include a field fabricated plenum of minimum 26 gauge galvanized steel.
 2. Inside of plenum shall be painted flat black.
 3. Plenum shall include inlet collar(s) for flexible round duct as indicated. Inlets shall include a balance damper.

2.11 MOTORIZED DAMPERS

- A. Motorized Dampers shall be:
 1. Rated per AMCA standard 500: Pressure drop rated in accordance with figure 5.3; leakage rated in accordance figure 5.5.
 2. Rated for up to 180 degrees F.
 3. 1/2" diameter x 2" long axles, cadmium plated steel (or hex or square).
 4. Stainless steel axle bushings.
 5. Blades securely attached to shaft.
 6. Linkage shall be concealed in frame and shall be plated steel bars with stainless steel pivots.
 7. Maximum pressure drop shall be rated for a 24"x24" test duct.
- B. Type A Motorized Dampers shall be equal to Ruskin CD-60 with the following features: Nailor 1120, American Warming VC-27 or approved equal by Arrow, Penn, or Greenheck shall be equally acceptable.
 1. Parallel blades.
 2. Allowable velocity of 3000 FPM (48"- 60" long blades) and 4000FPM (max. 48" long blades) and differential pressure of 3.5" W.G.
 3. Frame - 5" x 1" x 16 gauge galvanized steel hat channel.
 4. Blades - Airfoil shaped, double skin galvanized steel construction of 14 gauge equivalent thickness, maximum 6" wide. Blade extensions may be used on top and/or bottom blades to meet damper size requirements without diminishing free area.
 5. Seals - Extruded vinyl blade edge seals and flexible metal compressible jamb seals.
 6. Finish - Mill galvanized.
 7. Maximum pressure drop at 3000 fpm shall not exceed 0.30" W.G.
 8. Damper torque requirements shall not exceed 5 in-lbs per ft. for opposed blade dampers and 7 in-lbs per ft. for parallel blade dampers.
 9. Maximum Leakage per Sq.Ft. at 1" W.G. differential pressure: 3.0 CFM for dampers 12" to 24" wide and 2.0 CFM for dampers greater than 24" wide.
 10. Maximum single dampers section shall be 60" wide x 72" high.
 11. For multiple section dampers, each section shall be operated by a separate actuator.
 12. Mount actuators directly to a 1/2" diameter control shaft with outboard support bearing that extends 6" beyond the damper frame.
- C. Motorized damper actuators shall have the following features.
 1. Actuators shall be Belimo model AF24-SR or equivalent by Siemens or Siebe. No other substitutions allowed.
 2. Actuators shall be connected to the dampers as shown in details on the drawings. Provide all needed linkages and materials for a complete operating damper.
 3. Actuators shall be factory mounted and connected to the damper section(s).
 4. Size all actuators for minimum of 130% of the torque required to operate the damper(s).
 5. Maximum time for full stroke or return of 135 seconds. The spring return running time shall be approximately 40 seconds.
 6. Each actuator shall have a minimum torque of 133 in-lbs.
 7. The actuator shall have spring return for fail-safe operation. During normal operation the actuator shall not work against the force of the spring.

8. The actuator shall be powered by either 24 VAC or 24 VDC. Power consumption shall not exceed 6 watts. Actuator control shall be proportional by a 0 to 10 VDC or 4 to 20ma signal, with the addition of a 500 ohm resistor.
9. Provide a conduit connection for actuators located in mechanical rooms or outdoors and a 1 foot long plenum rated cable for connection to a junction box for actuators located in ceiling plenums.
10. Actuator shall have built in overload protection to prevent damage to the actuator when the actuator or damper reaches its end position. End switches are not acceptable.
11. Actuator shall be UL listed and labeled.
12. Actuator shall be designed for a minimum 60,000 open-close cycles and 1000 spring return cycles.

2.12 BALANCE DAMPERS

A. General

1. All balance dampers occurring in concealed ductwork, except those above removable ceilings, shall be installed with shafts vertical.
2. Provide control rod extending beyond the duct with a single locking quadrant for all volume dampers. Locking quadrant shall be continuously adjustable throughout a 90 degree operating range.
3. For dampers in ducts with liner, provide hat channel to match liner thickness; for dampers in ducts with external insulation, provide hat channel under locking quadrant same thickness as insulation.
4. Blade extensions may be used on top and/or bottom blades of Multi-blade dampers to meet damper size requirements without diminishing free area. Multi-blade dampers shall have opposed blades and shall be tested in accordance with AMCA standard 500, figure 5.3.

B. Single Blade Dampers shall be allowed in ducts up to 2.25 sq. ft.

1. Single Blade Dampers shall have 16 gauge galvanized steel or 0.090" aluminum reinforced blades, 16 gauge galvanized steel or 0.090" aluminum frames, 1/2" diameter (or hex or square) shafts that are minimum 2" long, and nylon or bronze axle bushings. Securely attach blades to shaft. Dampers shall be rated for up to 1,500 fpm and 1" differential static pressure. Provide volume dampers integral with "spin-in" where appropriate or indicated. Single blade dampers shall be Vent Products model 5101 (rectangular), model 5301 (round), or approved equal by Ruskin, Nailor, or American Warming.
2. Alternate Single Blade damper Construction: Similar construction to above except blade and shaft may be shop fabricated and mounted in duct (or spin-in) without a separate damper "frame." Provide shaft continuously through duct with locking quadrant on one end and end bearing on other end. End bearing shall be Young Regulator No. 656 or approved equal.

C. Where dampers occur in non-accessible space, such as above plaster ceilings, or within chases, extend damper rod to recessed cup with flush cover plate in the ceiling. Young Regulator #301, or equal. Alternately, provide rack and pinion controller with flexible wire connector to operate damper up to 50 feet away; provide all needed hardware at damper and remote location; provide 6 wrenches to Owner; for ceiling, wall or plenum mounting or as indicated on the plans; equal to Young Regulator Bowden Cable Controllers 270.

2.13 BACK DRAFT DAMPERS

A. Back draft dampers shall comply with the following:

1. Shall have minimum 2", 0.125" thick extruded aluminum frame reinforced for rigidity.
2. Aluminum blades of maximum 6" width.

3. Adjustable counterweight.
4. Cadmium plated steel shafts.
5. Blade shafts shall operate in ball bearings.
6. Hardware shall be cadmium plated steel with brass pins.
7. Dampers shall include blade edge seals. Leakage shall be less than 12 cfm per sq. ft. at ½ inch W.G.
8. Use multiple damper sections for sizes above 48" x 48".

- B. Back draft dampers shall be Ruskin model BD-6 or approved equal by NCA, Greenheck, or Nailor.

2.14 ACCESS DOORS

- A. Access doors for ductwork shall be minimum 22 gauge galvanized steel with a continuous piano type hinge and camlock(s) (1 for doors 16" and 2 for larger doors); air leakage shall not exceed 0.21 CFM per square foot at 1 inch static pressure. Doors shall be 24" x 24", except for small ducts, where doors shall be as large as practical. Doors shall include a seal between the door and frame and shall also include a seal between the frame and duct. Doors shall be Ruskin model ADH 12 or equal by Cesco Products (Minneapolis, Mn.), A.J Manufacturing, or approved equal.

2.15 LOUVERS

- A. The scheduled Ruskin louver selection is to establish the desired style, quality, type and performance. Equal products by NCA, Nailor, Vent Products, Air Balance, or Greenheck are acceptable.
- B. Louvers shall be constructed of aluminum with an anodized aluminum finish and shall include a matching sill extension.
- C. Blades shall be minimum 0.08" extruded aluminum and shall be 4" storm-proof design.
- D. Louvers shall bear the AMCA certified rating seal for air performance and water penetration.
- E. Water penetration shall not exceed 0.01 oz. of water per ft² in 15 minutes when tested in compliance with the standard described above at a free area velocity of 500 fpm.
- F. Maximum pressure drop shall not exceed 0.035" w.c. at a free area velocity of 500 fpm. Pressure drop rating shall include the birdscreen.
- G. Louver shall include ½" x ½" mesh 0.063" aluminum birdscreen.

2.16 LOUVERS (BRICK VENT)

- A. Manufacturers:
1. Greenheck
 2. Ruskin
- B. Louvers performance shall be AMCA Certified and shall meet or exceed the follow specifications:
1. Static pressure drop: 0.10" or less at 1000 FPM through free area.
 2. Minimum Free Area: 22% minimum.
- C. Type: 4 inch (100 mm) deep with blades on 45 degree slope, drainable, heavy channel frame, insect screen with 18 in x 14 in aluminum mesh.
- D. Fabrication: 0.125" thick extruded aluminum, factory baked enamel finish, color as selected by Architect.

PART 3 - EXECUTION

3.1 HANGING AND SUPPORTING DUCT WORK

- A. All ductwork shall be neatly supported and properly anchored to building construction so horizontal ducts are without sag or sway, vertical are without buckle and all are free from the possibility of deformation collapse or vibration.
- B. Install rigid round, rectangular, and flat oval metal duct with support systems indicated in SMACNA 2005 Tables 4-1 through 4-3 and Figures 4-1 through 4-9.
- C. Install single wall ductwork except where double wall ducts are indicated on the plans.
- D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection. Provide trapeze hanger diagonally under all elbows greater than 54 inches wide.
- E. Support vertical ducts at a maximum interval of 16 feet and at each floor.
- F. Upper attachments to structures shall have an allowable load not exceeding 1/4 of the failure (proof test) load.
- G. Hanger rods shall have double nuts and lock washers at all connections.
- H. Install concrete inserts prior to placing concrete.
- I. Install drilled inserts and powder actuated concrete fasteners after concrete is placed and completely cured. Obtain approval of the Engineer prior to using powder actuated concrete fasteners.
- J. Duct shall not be supported from metal roof deck.

3.2 DUCT INSTALLATION, GENERAL

- A. Duct System Pressure Class: Construct and install each duct system for the specific duct pressure classification indicated.
- B. Verify exact locations and space requirements of ducts at the site and coordinate work with other trades, before fabricating ductwork.
- C. Install ducts with the fewest possible joints.
- D. Use fabricated fittings for all changes in directions, changes in size and shape, and connections. Provide all drops, raises, transitions, or offsets as required, at no additional cost to the Owner, Architect or Engineer, due to obstructions. When additional offsets, etc., different from those shown are required, approval shall be obtained from the Engineer prior to proceeding. All size or shape transitions shall be made gradually with angle not to exceed 15 degrees on each side.
- E. Install branch take-offs tight to duct wall with projections into main duct kept to a minimum. Ragged edges projecting into the main duct shall not be allowed.
- F. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct usable space or block access for servicing building and its equipment.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities. The sheet metal work shall be coordinated with that of other trades in such a manner that when the installation is complete, all items are properly installed and are serviceable.

- H. Install insulated ducts with 1-inch clearance outside of insulation.
- I. Conceal ducts from view in finished and occupied spaces by locating in mechanical shafts, hollow wall construction, or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown.
- J. Coordinate layout with ceiling, lighting layouts, sprinklers and other piping.
- K. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- L. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with escutcheon of sheet metal flanges of same gauge as duct. Overlap opening on 4 sides by at least 2 inches.
- M. Branch Connections: Comply with SMACNA 2005 Figures 4-5 and 4-6.
 - 1. Install radius elbows and vaned elbows where shown on the plans. Radius elbows may be substituted for vaned elbows, but vaned elbows shall not be substituted for radius type unless approved in writing by the Engineer. 45 degree taps and other taps shall not be substituted for elbows.
- N. Outlet and Inlet Connections: Comply with SMACNA 2005 Figures 7-6, 7-7 and 10-1 and as indicated on plans.
- O. Flexible Connections at Fans: Comply with SMACNA 2005 Figure 7-8.
- P. Provide openings in ductwork where required to accommodate thermometers and temperature sensors.
- Q. Clean duct system and force high velocity air through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.
- R. During construction all open ends of installed ductwork shall be kept covered to prevent dirt and debris from entering ducts. Openings shall be covered with plastic sheeting held in place with duct tape. Any ducts stored on site shall be protected by keeping them raised off the ground.
- S. Ducts shall be neatly finished on the outside with all sharp edges removed. Inside surfaces shall be smooth with no projections into the air stream.
- T. All fasteners and attachments shall be made of the same material as the ducts or of corrosion-resistant material.
- U. Ducts up through 2" pressure class shall have all transverse duct joints sealed in compliance with the sealant manufacturer's recommendations and SMACNA procedures for Seal Class C. Ducts over 2" pressure class shall have transverse and longitudinal joints sealed in compliance with the sealant manufacturer's recommendations and SMACNA procedures for Seal Class A.
- V. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance. Dissimilar metals shall be connected with flanged joints made up with neoprene gaskets to prevent contact between metals. Flanges shall be fastened with bolts protected by ferrules and washers made of the same material as the gaskets.
- W. Where dampers are installed in ducts having external duct insulation, install damper locking quadrants with hat channel or of same depth as insulation to allow smooth operation of dampers.

- X. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

3.3 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Provide hanging materials that match the appearance of the exposed ducts.
- C. Remove any identification labels or markings from ducts so appearance of ducts at such locations matches the remainder of the ducts.
- D. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- E. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- F. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- G. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.4 LEAKAGE TESTING

- A. Ducts, plenums, and casings shall be tested and made substantially airtight at static pressure indicated for the system before covering with insulation or concealing in masonry. The term, "substantially airtight," shall be construed to mean that no air leakage is noticeable through the senses of feeling or hearing.

3.5 DUCT CLEANING

- A. Clean new duct system(s) to remove oil film and dust before testing, adjusting, and balancing.

3.6 FLEXIBLE ROUND DUCT INSTALLATION

- A. Application
 1. Flexible round ductwork may be used where shown on the drawings.
 2. Provide low pressure flex ducts in ducts rated 2" static pressure class or less.
 3. Provide high pressure flex ducts in ducts rated over 2" static pressure class.
 4. Flexible duct shall not pass thru any wall, floor or ceiling.
- B. Slide vapor barrier and insulation away from ends. Secure flex duct to diffusers and main duct takeoff with flame retardant nylon or stainless steel draw bands. Slide vapor barrier and insulation back over flex duct and secure in place with draw band or duct tape. Apply duct sealer if necessary to obtain a leak tight connection. Nylon cable ties shall be 0.19 inch width minimum, with standard cross-section and shall comply with UL-181 or UL - 2043.
- C. All flexible duct shall be routed and supported in such a manner that the duct is not flattened in any area and that full cross sectional area is maintained. All bends shall be made in such a manner that the ratio of the center line radius of the bend to the inside diameter of the duct is not less than 1. Support flexible ducts from building structures in accordance with SMACNA 2005 Figure 3-10 or 3-11. Provide a sheet metal saddle between the insulation and strap, to prevent duct from sagging excessively and from resting on lights, ceilings, etc.
- D. Where flex duct turns 90°, provide a 90° sheet metal elbow or support the flex duct through the turn with a flexible elbow support.

- E. All bends shall be made so that the ratio of the center line radius of the bend to the inside diameter of the duct is not less than 3.
- F. Maximum length of flexible ducts shall be 8 feet unless otherwise indicated.

3.7 FLEXIBLE CONNECTOR INSTALLATION

- A. Flexible connectors shall be provided where fans, air handling units, fan terminal units, fan coil units, and rooftop units connect to ducts or casings to prevent transmission or vibration to ductwork.
- B. Flexible connectors shall fit tightly around ducts and fans and shall be securely bolted in place.
- C. Joints between flexible connectors and duct or fan shall be sealed with duct sealer.

3.8 BALANCE DAMPER INSTALLATION

- A. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts. Install minimum 2 duct widths from duct take-off. Provide balance dampers where shown or where required to properly balance and direct air flow.
- B. Every supply air outlet shall have a balance damper at the branch duct takeoff to the supply outlet regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
- C. Exhaust grilles shall have a balance damper at the branch duct connection to the main duct.
- D. Install damper control devices on stand-offs where required to allow complete coverage of insulation.

3.9 LOUVER INSTALLATION

- A. Install louver and sill extension in building opening where indicated. Secure louver to structure in accordance with manufacturer's instructions.
- B. Seal between louver and building opening to prevent moisture entry.
- C. Connect ducts to louvers, plenums, and casings and seal to prevent leakage.
- D. Provide drain in ducts, plenums, and casings to allow moisture that bypasses the louver to be removed.

3.10 BACK DRAFT DAMPER INSTALLATION

- A. Back draft dampers shall be installed on exhaust fans where scheduled and other locations where indicated on drawings.

3.11 MOTORIZED DAMPER INSTALLATION

- A. Install motorized dampers per manufacturer's instructions.
- B. Actuators shall be installed on the outside of ducts unless otherwise indicated. Provide access doors where damper motors are concealed in ducts.
- C. Install damper control devices on stand-offs where required to allow complete coverage of insulation.

3.12 ACCESS DOOR INSTALLATION

- A. Provide access doors in ducts at fire dampers, where actuators for motorized dampers are concealed inside ducts, and at other items located in ducts or plenums where access into ductwork is required for maintenance or installation of work by other trades.

3.13 TEST OPENING INSTALLATION

- A. Provide test openings in ductwork for testing and balancing.
- B. Patch insulation, ductwork, and housings, using materials identical to those removed.
- C. "Plastic Plugs" may be used to seal openings where duct traverses are made.
- D. Provide Pitot tube openings where required for testing of systems. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

3.14 INSTALLATION OF DUCT SMOKE DETECTORS

- A. Install duct detectors furnished in Section 260980 per manufacturer's instructions in ductwork or air handling units where indicated. Where a duct is not wide or high enough for the smoke detector to be installed, provide a transition in the duct to allow the smoke detector installation.

3.15 AIR DEVICE INSTALLATION

- A. Air direction patterns shall comply with those shown and adjustments shall be made to prevent impingement of moving air on walls. Coordinate locations of outlets and inlets with other contractors to avoid interferences and to effect proper installation. Outlets in lay-in ceilings shall be located as close to positions shown on plans as the ceiling grid will allow; notify Architect and Engineer before proceeding if ceiling grid will not allow layout shown.
- B. Diffusers and grille layouts shown on the plans have been coordinated with the layout of the ceiling grid to establish the desired arrangement of grilles and diffusers. Prior to installing any ductwork which would be affected by the grid layout, verify the grid layout with the Architectural ceiling plans and the actual ceiling layout.
- C. Provide a square-to-round or round-to-square adapter with the air device where necessary to connect to the ductwork shown.
- D. Fasten air device frames and borders to drywall ceilings and walls where required. Provide a plaster ring to allow lay-in style devices to be used for drywall installations.
- E. Clean construction dirt from all air devices.
- F. Provide extension duct collar from ductwork to air devices connected to rigid duct. Fasten with sheet metal screws and seal. Where air devices are installed on exposed ductwork, provide 4" extension collar with dimensions equal to the outside dimensions of the air device and mounting flange turned inward.
- G. Diffusers shall be connected to flexible ductwork as follows:
 - 1. Fasten frames and borders to drywall ceilings where required.
 - 2. Slide flexible duct over collar of diffuser. Secure flexible duct to duct collar with flame retardant nylon cable tie(s) or stainless steel drawbands. Secure with an installation tool approved by the cable tie manufacturer. Nylon cable ties shall be 0.19 inch width minimum, with standard cross-section and shall comply with UL-181 or UL - 2043.
 - 3. Clean construction dirt from diffusers.
 - 4. Remove damper operator knob and turn over to Owner's Representative.
- H. Diffusers connected to rigid duct shall be installed as follows:
 - 1. Fasten frames and borders to drywall ceilings where required.

2. Fasten extension duct collar to ductwork with sheet metal screws (and seal with approved duct sealer).
3. Fasten duct ring to extension duct collar with sheet metal screws.
4. Clean construction dirt from diffuser.

I. Grilles and Registers shall be connected to the ductwork as follows:

1. Cut hole in return or exhaust duct.
2. Fasten extension duct collar to ductwork.
3. After ceiling or wall is installed, install register with sheet metal screws.
4. Check to see if sponge rubber gasket is drawn up against wall or ceiling, forming an air tight seal. If not, reassemble and check.
5. Clean construction dirt from register.
6. Remove damper operator key from register and turn over to Owner's Representative.

J. All grilles, registers and diffusers shall be left in a wide open position.

K. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, regardless of whether dampers are specified as part of the diffuser, or grille and register assembly.

L. Paint ductwork visible behind air outlets and inlets matte black.

M. Provide supplemental "tees" for the ceiling grid where diffusers are a different size than the ceiling tiles.

3.16 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a primer that is compatible with the duct material.

3.17 SHOP APPLICATION OF LINER IN RECTANGULAR DUCTS

A. The duct liner shall be cut to assure snug corner joints and installed so the black surface of the liner faces the air stream. Fold and compress liner in corners to assure butted edge overlapping.

B. Adhere a single layer of indicated thickness of duct liner with 100 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.

C. On horizontal runs, tops of ducts over 12" wide and/or sides over 16" high shall be additionally secured with Gripnail or welded pins and speed clips on a maximum of 15" centers.

D. On vertical runs, Gripnail or welded pins and speed clips shall be spaced on a maximum of 15" centers on all duct dimensions over 12".

E. Mechanical fasteners shall start within 2" of leading edge of each section, and within 3" of the leading edge of all cross joints within the duct sections. Mechanical fasteners shall be flush with the liner surface. Clips shall be drawn down flush only and not so as to compress the liner and cause the leading edge to raise up.

F. All exposed edges and the leading edge of all cross joints of the liner shall be sealed with edge sealer.

G. Butt transverse joints without gaps and coat joint with adhesive.

H. Longitudinal joints in rectangular ducts shall not occur except at corners of ducts, unless the size of the duct and standard liner product dimensions make longitudinal joints necessary.

- I. Secure transversely oriented liner edges facing the airstream with metal nosings that are either channel or "Z" profile or are integrally formed from the duct wall at the following locations:
 - 1. Fan discharge and upstream edges of transverse joints within 40 feet of the fan discharge.
 - 2. Where lined ducts are preceded by unlined ductwork.
- J. Terminate liner with duct build outs (metal hat sections) installed in ducts to attach dampers, turning vane assemblies, and other devices. Secure build outs to the duct wall with bolts, screws, rivets, or welds. Terminate liner at fire dampers at connection to fire damper sleeve through fire separation.
- K. Duct liners having a rough surface that produces an Air Friction Correction Factor greater than specified shall have the duct oversized by the sheet metal contractor to achieve the Air Friction Correction Factor indicated.
- L. Do not use multiple layers of duct liner unless approved by the Engineer in writing. If multiple layers are used, the following additional steps shall be taken:
 - 1. Adhere bottom layer of duct liner in normal manner.
 - 2. Adhere top layer of duct liner to bottom layer using a minimum of 90% adhesive coverage.
 - 3. Treat the leading edges of the duct liner with metal nosing to prevent separation of the two layers.
 - 4. Use mechanical fasteners of the proper length for the double layer.
- M. The following ducts require internal lining with a 1.5 pdf density and liner thickness indicated:
 - 1. All new rectangular supply and return ductwork - 1" thick.
 - 2. All rectangular supply ductwork from the OAP and ERU - ½" thick.
- N. External Duct Insulation: See Section 230200 - Mechanical Insulation for application requirements.
- O. Ductwork Located Outdoors
 - 1. Ductwork shall be internally lined with duct liner as described above.
 - 2. Exterior of ducts shall be insulated and jacketed as described in See Section 230200 - Mechanical Insulation.

END OF SECTION 230900

SECTION 230910 – START-UP, CLEANING AND TESTING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Furnish all labor, services, materials and related items necessary to complete the start-up, cleaning and testing work indicated on the drawings and/or specified herein. Work to be performed shall include, but not be limited to, the following items:
 - 1. All Air Systems
 - 2. Natural Gas Piping
 - 3. Fuel Oil Piping
 - 4. Condensate Drains

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - General Mechanical Conditions.

PART 2 - PRODUCTS

2.1 PIPE CLEANING CHEMICALS

- A. Vulcan Precleaner or approved equal by Nalco or Calgon.

PART 3 - EXECUTION

3.1 START-UP OF SYSTEMS AND EQUIPMENT

- A. Before any systems, or parts of systems are placed into unattended operation, they shall be completely installed, pressure tested, cleaned, flushed and balanced with all operating and safety controllers installed, calibrated and operational.
- B. When started, all motors shall be checked for proper rotation, speed, and amperage. If overloading is indicated, immediate corrective measures shall be taken to prevent damage to the motor.
- C. Before systems are operated, all bearings shall be lubricated and all other liquid levels and pressures checked and if necessary corrected.
- D. Contractor shall start-up all systems and equipment and place all systems into operation. Any equipment, pieces of equipment, controls, etc., damaged or not operating properly shall be replaced at this contractor's expense.
- E. Contractor shall verify proper and safe operation of all equipment, components, controls and control circuits before any system is left unattended.
- F. Whenever air systems are operated, air filters shall be in place. Air systems shall not be operated at any time without filters.

3.2 PIPE SYSTEMS TESTING

- A. Except for those pipes hereinafter listed, all piping installed by this Contractor shall be pressure tested. (See Plumbing Section for testing of plumbing piping.)
- B. Perform the following tests on refrigerant piping:
 - 1. See test requirements in Section 230150 "Refrigerant Piping."

- C. The following pipes do not require a pressure test:
 - 1. Air Handling Unit and DX coil condensate drains.
- D. Any item which might be damaged by the pressure test shall be removed from the system during the test, or isolated from the test.
- E. Gauges used for testing shall be tested for accuracy, and then installed as close as possible to the low point of the system to be checked.
- F. No leakage is permitted. Leaks shall be repaired and the lines retested.
- G. Any lines changed after testing shall be retested.
- H. Test data shall be recorded on a standard form.
- I. While piping is under test, care shall be taken that excessive pressure does not occur due to increase of ambient temperature.
- J. Test Pressure and Medium:

LINE SERVICE	MEDIUM	TEST PRESSURE PSIG
Natural Gas	Air	100
Fuel Oil	Air	100

3.3 CLEANING

- A. Adequate precautions shall be taken during storage and installation to keep the inside of all pipes, valves and fittings free from foreign materials.
- B. The inside of all pipes, valves, and fittings shall be smooth, clean, free from blister, loose mill scale, sand, dirt and other foreign material.
- C. This Contractor shall clean all piping installed by him.
- D. Natural gas and fuel oil piping shall be cleaned with compressed air. Piping shall be thoroughly blown clean. When complete, all dirt legs, strainers, etc., shall be cleaned. Any items in the piping system, such as gas trains or equipment, which could be affected by either the pressure or dirt shall be disconnected during the cleaning operation.

3.4 TURN OVER TO OWNER

- A. Perform the following before operating the system:
 - 1. Open manual valves fully.
 - 2. Inspect pumps for proper rotation.
 - 3. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
- B. When the system is turned over to the Owner, all systems shall have been started, tested, balanced and checked and proven to be fully operational in every respect.
- C. When the system is turned over to the Owner, all bearings shall have been recently lubricated, oil levels checked and oil added if necessary, liquid levels and pressures checked and corrected, flow rates checked and corrected, R.P.M.'s verified, belts tightened and aligned, and all controls and control sequences checked, verified operational and if necessary, corrected.

D. When the system is turned over to the Owner, all air filters shall be replaced with clean filters.

END OF SECTION 230910

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SECTION 230930 – TESTING AND BALANCING

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish all labor, services, materials and related items necessary to complete the testing and balancing (TAB) work indicated on the drawings and/or specified herein. The scope of work shall include:
 - 1. Balancing of all air movement systems.
 - 2. Adjusting all air devices to prevent drafts on occupants or as otherwise indicated.

1.2 RELATED DOCUMENTS

- A. All drawings and applicable provisions of Division 0 Bidding Requirements and Division 1 General Requirements apply to work of this Section.
- B. Section 230000 - Mechanical General Conditions.
- C. Section 230010 - Mechanical Basic Materials and Methods.
- D. Section 230020 - Vibration Isolation.

1.3 All instruments used by this agency shall be accurately calibrated and maintained in good working order.

1.4 The balance work shall be performed by an AABC (Associated Air Balance Council) or a NEBB (National Environmental Balance Bureau) certified firm. All work shall be done in compliance with the standards of the certification. All balance work shall be done under direct supervision of a qualified heating and ventilating engineer employed by them. All work shall also comply with the ASHRAE Standard 111 recommendations pertaining to measurements, instruments, testing, adjusting and balancing.

1.5 The balance firm shall have a minimum of 5 year's experience balancing similar systems.

1.6 If requested, the tests shall be conducted in the presence of the Engineer or their representative.

1.7 REFERENCES

- A. AABC - National Standards for Field Measurement and Instrumentation, Total System Balance.
- B. ASHRAE - 1984 Systems Handbook: Chapter 37, Testing, Adjusting and Balancing.
- C. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental Systems.

1.8 SUBMITTAL

- A. Provide submittals under provisions of Section 230000.
- B. Within 30 days of award of the contract, submit:
 - 1. Name and qualifications of testing, adjusting and balancing agency for approval by the Engineer.
 - 2. Submit sample balance report forms and detailed procedures for approval by the Engineer.
 - 3. Forms shall be representative for all the tests. Formulas and data to be used for determining heat exchange capacities, where required, shall be included.
- C. Submit copies of final reports to the Engineer for inclusion in operating and maintenance manuals.
- D. Provide reports in soft cover, letter size, multi-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings

with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

E. Reports shall include the following information:

1. TAB Company name, address, and telephone number.
2. Project name, location, Project Architect, Project Engineer, and Project Contractor.
3. Project altitude.
4. Instrument List:
 - a. Instrument.
 - b. Manufacturer.
 - c. Model.
 - d. Serial number.
 - e. Range.
 - f. Calibration date.

1.9 QUALITY ASSURANCE

- A. Agency shall be company specializing in the adjusting and balancing of systems specified in this Section with minimum three years documented experience. Perform work under supervision of AABC Certified Test and Balance Engineer.
- B. Total system balance shall be performed in accordance with AABC National Standards for Field Measurement and Instrumentation, Total System Balance.

1.10 SCHEDULE

- A. Sequence work to commence after completion of systems. Schedule completion of TAB work before Substantial Completion of Project.
- B. Air balance reports shall be submitted a minimum of 5 days prior to substantial completion.

1.11 PREPARATION FOR TESTING AND BALANCING

- A. The Mechanical Contractor shall bring the work to a state of readiness for testing and balancing all equipment and systems by doing the following:
 1. Install air terminal devices.
 2. Install all balancing devices. Leave them accessible, readily adjustable, and in the open position.
 3. Verify lubrication of all equipment.
 4. Permanent instrumentation to be operational.
 5. Check rotation and alignment of rotating equipment and tension of belt drives.
 6. "Start-up" HVAC equipment and continue operating the equipment during the testing and balancing.
 7. Verify rating of overload heaters in motor starters.
 8. Set control points of automatic controls and check calibrations and adjustments.
 9. Repair or replace at this contractor's expense components of system which do not function properly.
- B. Mechanical Contractor shall assist the balance firm as follows:
 1. Provide TAB firm with copy of the HVAC plans, specifications and approved equipment submittals.
 2. Change, at the Mechanical Contractor's expense, pulleys, belts, drive, etc., required to obtain correct air balance.
 3. Add, at the Mechanical Contractor's expense, dampers and/or valves as required by the TAB firm to correctly balance the HVAC systems.
 4. Repair duct leaks identified by the TAB firm.

5. Put all HVAC equipment and systems into operation and continue the operation during each working day of TAB, as required.
6. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
7. Provide temperature and pressure taps according to the Construction Documents for TAB testing.

1.12 DEMONSTRATION

A. Demonstrate as follows:

1. The TAB Firm shall be prepared to demonstrate to the Engineer and the Owner that actual conditions match the balancing report. At the Engineer's discretion:
 - a. Retest no more than 30% of the supply, return and exhaust outlets to demonstrate that they are reading what the balance report indicates.
 - b. Retest no more than 30% fan/pump, etc., systems to demonstrate that they are operating at conditions indicated in the balancing report.
 - c. Retest no more than 30% of controls relative to the mechanical equipment to demonstrate that they are operating properly.
 - d. Retesting shall be done in cooperation with the Engineer and the Owner's personnel and in their presence if requested.

PART 2 - PRODUCTS

2.1 MEASUREMENTS AND INSTRUMENTATION

- A. Provide all required instrumentation to obtain proper measurements, calibrated to the tolerances specified in the referenced standards. Instruments shall be properly maintained and protected against damage.
- B. Provide instruments meeting the specifications of the referenced standards.
- C. Use only those instruments which have the maximum field measuring accuracy and are best suited to the function being measured.
- D. Apply instrument as recommended by the manufacturer.
- E. Use instruments with minimum scale and maximum subdivisions and with scale ranges proper for the value being measured.
- F. When averaging values, take a sufficient quantity of readings which will result in a repeatability error of less than 5 percent. When measuring a single point, repeat readings until 2 consecutive identical values are obtained.
- G. Take all reading with the eye at the level of the indicated value to prevent parallax.
- H. Use pulsation dampeners where necessary to eliminate error involved in estimating average of rapidly fluctuation readings.
- I. Take measurements in the system where best suited to the task.
- J. Prepare and submit a profile of the air flow across all coils in all air handling units.

PART 3 - EXECUTION

- 3.1 The TAB firm shall provide the following services:

- A. Test and balance the air distribution and exhaust system to within 10% of design conditions (except AHU, FTU, and Heat Pump Unit supply fans shall be tested to within -0% to +10%) in accordance with the following:
1. Measure and record the following initial and final fan data for each air handling unit and exhaust fan: fan total static pressure, fan RPM, fan motor current and total CFM.
 2. Make adjustments in fan RPM as required to obtain the required total CFM, outside air CFM and return air CFM.
 3. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
 4. Adjust balance dampers as necessary for design air flow from each diffuser and to each exhaust and return grille. Use volume control devices on air devices to regulate air quantities only to extent that adjustments do not create objectionable sound levels. Effect volume control by duct mounted dampers. Report required CFM and resultant CFM after final adjustments. Report percent of design air flow.
 5. Adjust balance dampers as necessary for design air flow from each diffuser and to each exhaust and return grille. Use volume control devices on air devices to regulate air quantities only to extent that adjustments do not create objectionable sound levels. Effect volume control by duct mounted dampers. Report required CFM and resultant CFM after final adjustments. Report percent of design air flow.
 6. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts and install test ports.
 7. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
 8. Adjust deflection vanes on all air devices as indicated on plans and schedules and to minimize drafts in all areas. Adjust return air devices to block line of sight into return air duct or plenums.
 9. Examine HVAC equipment with functioning controls is ready for operation and terminal units, such as variable-air-volume boxes, are accessible and their controls are connected and functioning.
- B. Test and balance the control system and make temperature tests in accordance with the following:
1. In cooperation with the control contractor, check all devices in the control system for function and calibration.
 2. Measure temperatures (EAT and LAT as applicable) at all rooftop units, coils, etc. when this equipment is operating under maximum load or conditions similar to maximum load for both heating and cooling.
- C. Motor rotation and speed shall be checked and recorded for all motors.
- D. Proper air flows shall be demonstrated in minimum outside air, full outside air (economizer), and intermediate positions. Intermediate positions shall be carefully observed to insure that no overloading or other objectionable conditions occur. Should any objectionable conditions occur, the Engineer shall be notified of the conditions and their causes.

- E. Submit reports of discrepancies, deficient or uncompleted work by others to the GC and Owners Rep at least once a week prior to submitting a draft test and balance report.
- F. Submit draft test and balance reports. Coordinate with Engineer and MC to resolve deficiencies.
- G. Submit final test and balance reports when deficiencies have been resolved.

END OF SECTION 230930

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