

SECTION 23 21 13 – HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions and the following Specification sections apply to all Work herein:

1. Section 23 05 00 Common Work Results for HVAC
2. Section 23 05 48 Vibration and Seismic Controls for HVAC Piping & Equipment
3. Section 23 05 93 Testing, Balancing and Adjusting
4. Section 23 07 00 HVAC Insulation
5. Section 23 21 23 Pumps
6. Section 23 21 31 Tanks and Vessels.
7. Section 23 25 00 Water Treatment Systems
8. Section 23 52 00 Boilers
9. Section 23 64 16 Centrifugal Water Chilling Units
10. Section 23 65 00 Cooling Tower

B. Refer to Division 1 Specifications for the following LEED requirements:

1. Commissioning
2. Commissioning Plan
3. Commissioning Checklists

1.2 SUMMARY

A. Furnish and install all pipe, valves, temperature control (PICV) valves & actuators, fittings and accessories herein specified and as indicated on the Drawings, complete with all appurtenances required for a complete and operating system.

1.3 REFERENCE STANDARDS

A. All pipe, valves, fittings and accessories shall be designed, manufactured and tested in accordance with the latest applicable industry standards including the following:

ASTM	
ANSI	B16.22, B16.3, B16.9, B31.1 and B36.10
ANSI	A 112-26-1M
AWS	American Welding Society
MSS SP-58	Pipe Hangers and Supports: Materials, Design, Manufacture, Selection Application, and Installation.
MSS SP-80	Bronze Gate, Globe, Angle and Check Valves
MSS SP-110	Ball Valves Threaded, Socket Welding, Solder Joint, Grooved and Flared Ends

B. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the authorities having jurisdiction, and suitable for its intended use on this Project.

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C. LEED Reference Standards:

1. LEED Reference Guide for New Construction – NC, Version ???X.X
2. LEED Reference Guide for Existing Buildings – EB, Version ???X.X
3. LEED Reference Guide for Commercial Interiors – CI, Version ???X.X
4. LEED Reference Guide for Core & Shell – CS, Version ???X.X
5. SMACNA "IAQ Guidelines for Occupied Buildings Under Construction"

1.4 LEED REQUIREMENTS

- A. Comply with the requirements of Section 23 05 00, Common Work Results for HVAC, Paragraph 1.4.

1.5 SUBMITTALS

- A. The following submittal data shall be furnished according to the General Conditions and Section 23 05 00 and shall include, but not be limited to:

1. Schedule of Pipe and Fitting Materials, complete with typical mill reports.
2. Pipe Cleaning Report.
3. Gate Valves, Globe Valves, Ball Valves, Butterfly Valves, Check Valves and Strainers.
4. Thermometers, Gauges and Test Ports.
5. Galvanized Pipe.
6. Pipe fabrication drawings and cut sheets for all refrigerant piping showing all specified fittings and accessories, pipe lengths and pipe sizes. Submit line sizing calculations approved by compressor unit manufacturer's application engineering department prior to installation of systems.
7. Cut/Roll Grooved Couplings and Fittings.
8. Subcontractor's Roll and Cut Groove Machine Certifications.
9. Bypass Filters.
10. Press-Connect Fittings.

B. LEED Submittals:

1. Credit EQ 4.1: Manufacturer's product data for interior sealants, sealant primers, and adhesives, including printed statement of VOC content and Material Safety Data Sheet (MSDS). VOC content shall be clearly indicated via highlight, clouds, arrows, etc. within the body of the submittal and should be clearly stated on a front cover page for each product in the submittal/

- C. The manufacturer shall include a specification compliance review report as described in Section 23 05 00. The compliance review will be a paragraph-by-paragraph review of the specifications with the following designations "C", "D", "E" or "N/A" marked in the right-hand margin beside each paragraph.

1.6 WARRANTY

- A. Comply with the requirements of the General Conditions and Section 23 05 00.

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PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Prior to purchase of any piping and fitting materials manufactured outside the United States, the Subcontractor shall submit complete certifications and typical mill reports written in English for review. Any foreign pipe delivered to the job site shall bear identification and mill heat markings and the Subcontractor shall make available the corresponding mill test reports.

- B. In addition to the requirements for foreign pipe of Paragraph 3.01L. above the Subcontractor shall submit a 12" long Sample of each type and manufacturer of all foreign galvanized pipe material to be installed on this Project to a certified metallurgy laboratory for complete properties and strength analysis. The Samples shall be cut from pipe stored at the Project Site or in the Subcontractor's fabrication facilities. The pipe shall be identified as to intended use, ASTM designation, grade, schedule, type, Project name, the Subcontractor and the date Sample was obtained. If the pipe is coated, such as galvanized, the thickness and properties of the coating shall be determined. A certified report of the test data shall be submitted to the Engineer for review. The cost of the testing shall be paid by the Subcontractor. The certified laboratory shall be subject to approval by the Owner and Engineer prior to testing. Any pipe that does not comply with the material standards specified herein shall be removed. See Section 23 05 00 for certification and submittal requirements.

- C. If it complies with these Specifications, all above ground chilled water, heating hot water [steam supply and condensate], [diesel engine exhaust] and condenser water piping manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:
 - 1. Black Steel Piping
 - a. Laclede
 - b. LTV
 - c. Maverick
 - d. Newport
 - e. Sawhill Tubular
 - f. Tex-Tube
 - g. U.S. Steel
 - h. Wheatland

 - 2. Copper pipe
 - a. Cerro
 - b. Halstead
 - c. Mueller
 - d. Wolverine

- D. If it complies with these Specifications, all screw, grooved and compression fittings manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:

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<ol style="list-style-type: none"> 1. Anvil 2. Ward 3. Viega 4. Grinnell 5. Ladish 6. Hackney 7. Tube Forgings of America 8. Tube-Line 9. Tube-Turn 10. Victaulic 11. Weld Bend 		
E.	<p>If it complies with these Specifications, all flanges manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>	
	<ol style="list-style-type: none"> 1. Cofer Flange 2. Federal Flange 3. Hackney 4. Ladish 5. National Flange 6. Victaulic 	
F.	<p>If it complies with these Specifications, all copper pipe fittings and accessories manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>	
	<ol style="list-style-type: none"> 1. Elkhart 2. Mueller 3. Nibco 4. Viega. 	
G.	<p>If it complies with these Specifications, all weld fittings manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>	
	<ol style="list-style-type: none"> 1. Anvil 2. Bonney Forge 3. WFI 4. Grinnell 5. Tube Forgings 6. Tube-Turn 7. Wheeling 	
H.	<p>If it complies with these Specifications, all pipe joint and anti-sieze compounds manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>	

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<ol style="list-style-type: none"> 1. Crane 2. LACO 3. Rector-Seal 4. WKM 		
<p>I. If it complies with these Specifications, all gasket materials manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>		
<ol style="list-style-type: none"> 1. J. M. Clipper 2. Crane 3. Dallas Gasket 4. Garlock 		
<p>J. If it complies with these Specifications, all pre-insulated piping manufactured in the United States [or approved equal pipe manufactured outside the United States subject to the restrictions specified herein in Part 3 – Execution] by one of the following manufacturers or approved equal will be acceptable:</p>		
<ol style="list-style-type: none"> 1. Energy Task Force 2. Insul-Pipe 3. Perma-Pipe 4. Ric Wil 5. Rovanco 6. Thermacor. 		
<p>K. If it complies with these Specifications, all drain piping specialties manufactured by one of the following manufacturers or approved equal will be acceptable:</p>		
<ol style="list-style-type: none"> 1. Quick disconnect couplings 2. SealFast 3. Huddleston Equipment Co. 4. Andrews 		
<p>L. If it complies with these Specifications, all steam piping specialties manufactured by one of the following manufacturers or approved equal will be acceptable:</p>		
<ol style="list-style-type: none"> 1. Steam Traps: <ol style="list-style-type: none"> a. Armstrong b. McDaniel c. Sarco d. Watson. 2. Strainers: <ol style="list-style-type: none"> a. Mueller Steam Specialty Company b. Crane c. Grinnell d. Keckley e. Zurn. 		

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3.	Steam Vacuum Breakers:	
	<ul style="list-style-type: none"> a. Crane b. Jenkins c. Nibco/Scott d. Stockham e. Walworth 	
4.	Steam Pressure Reducing Valves:	
	<ul style="list-style-type: none"> a. Spirax Sarco b. Leslie c. O.C. Keckley d. Spence 	
5.	Steam and Condensate Valves	
	<ul style="list-style-type: none"> a. Bray/McCannaLok b. Dezurik c. Keystone d. Posi-Seal. 	
M.	If it complies with these Specifications, all chilled, heating hot water and condenser water valves manufactured by one of the following manufacturers or approved equal will be acceptable:	
	1. 150 Psig Working Pressure, Above Ground:	
	<ul style="list-style-type: none"> a. Nibco b. Kitz c. Flow Design, Inc. d. Apollo e. AMRI f. Bray/FlowTek g. Jamesbury h. Milwaukee i. Nexus Valve j. Centerline k. Demco l. Dezurik m. Grinnell n. Keystone o. Victaulic p. Gruvlok q. Mission r. Muessco s. Norris t. Stockham u. Weco. 	
	2. 150 PSIG Working Pressure, Below Ground (Chilled Water):	

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	a. Tyco/Pratt	
3.	300 and 400 Psig Working Pressure (Chilled, Heating Hot Water and Condenser Water):	
	a. Apollo	
	b. Flow Design Inc.	
	c. Bray/Flow-Tek	
	d. Jamesbury	
	e. Kitz	
	f. Milwaukee	
	g. NIBCO.	
	h. Bray/McCannaLok	
	i. Dezurik	
	j. Grinnell-Winn BFV	
	k. Crane-Flowseal MS	
	l. Jamesbury	
	m. Keystone	
	n. Posi-Seal	
	o. Stockham	
	p. Tuflin.	
	q. Victaulic	
	r. Gruvlok.	
4.	Factory built piping assemblies	
	a. Flow Design Inc.	
	b. Nexus Valve	
	c. HCI	
N.	If it complies with these specifications, all refrigerant piping, fittings and accessories manufactured by one of the following manufacturers or approved equal will be acceptable:	
	1. Mueller	
	2. Chase	
	3. Anaconda.	
	4. Henry Valve Company	
	5. Sporlan Valve Company	
O.	If it complies with these Specifications, all miscellaneous piping accessories manufactured by one of the following manufacturers or approved equal will be acceptable:	
	1. Automatic Air Vents	
	a. Sarco	
	2. Pipe Hangers and Supports	
	a. B-Line	
	b. Anvil International, Inc.	
	c. Michigan Hanger	
	d. National	
	e. Phd	

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	f.	Tolco.
3.		Thermometers
	a.	Moeller Instrument Company, Inc.
	b.	Miljoco
	c.	Moeller
	d.	Trerice Winters
	e.	Weiss
	f.	Weksler
4.		Pressure Or Temperature Test Plugs
	a.	Flow Design Inc.
	b.	Nexus Valve
	c.	Texas Fairfax
	d.	Pete's Plug
	e.	Sisco
	f.	Miljoco
	g.	Watts
5.		Gauges and Gauge Stop Valves
	a.	Ashcroft
	b.	Marsh
	c.	Midwest
	d.	Moeller
	e.	Taylor
	f.	Trerice
	g.	Weiss
	h.	Winters
	i.	Weksler.
	j.	Orange Research, Inc.
	k.	Dwyer
6.		Check Valves
	a.	Jenkins
	b.	Gruvlok
	c.	Hammond
	d.	Keckley
	e.	Kitz
	f.	Nibco
	g.	Walworth
	h.	Watts
	i.	Apco
	j.	Cpv
	k.	Mission
	l.	Muessco
	m.	Techno Corporation
	n.	Victaulic

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	o. Williams-Hager	
7.	Strainers:	
	a. Crane	
	b. Flow Design Inc.	
	c. Gruvlok	
	d. Keckley	
	e. Mclear	
	f. Muessco	
	g. Victaulic	
	h. Watts	
	i. Zurn.	
P.	If it complies with these Specifications, all branch pressure reducing valves manufactured by one of the following manufacturers or approved equal will be acceptable:	
	1. Cla-Val Co.	
	2. JRG Gunzenhauser	
Q.	If it complies with these Specifications, all bypass filters manufactured by one of the following manufacturers or approved equal will be acceptable:	
	1. Filterite Corporation	
	2. Harmsco	
	3. Nowata	
2.2	CHILLED WATER, HEATING HOT WATER AND CONDENSER WATER PIPING (ABOVE GROUND)	
A.	This Project will utilize pressure classes for various water piping systems. Piping shall conform to the requirements of the working pressures as indicated in the paragraph titled "Design Conditions" in Section 23 05 00.	
B.	Carbon Steel Pipe 4" and smaller shall be ASTM A 53 Grade A Furnace Weld or ASTM A 53 Grade B ERW black pipe manufactured [in the United States] by a pipe mill that holds an in-force American Petroleum Institute license [and can be of domestic or foreign origin]. ERW pipe must be heat treated to a minimum of 1,000°F such that the seams are annealed and there is no un-tempered martensite. Each piece of pipe shall bear the mill name or mark, the specification, the grade, the method of production (type), the size/wall, the country of origin and the applicable heat number. All pipe delivered to the job shall be accompanied by the applicable Mill Test Certificate, which shall correlate with stenciled information on the pipe. If pipe is cut into smaller pieces by the contractor then the mill name and heat number must be transferred to the cut piece. [All piping shall be subject to the restrictions specified herein in Part 3 - Execution. Pipe manufactured in the Peoples Republic of China is not allowed.]	
C.	HVAC pipe 2" and smaller, serving fan coil units, unit heaters, fin tube and fan powered terminals, may be copper Type "K" with brazed joints for pressure classes through 300 psig. Pipe shall be ASTM B 88-72, H23.1-59 Type "K" hard drawn seamless copper water pipe. Connection from steel to copper shall be a dielectric nipple or waterway entering the shutoff valve. Copper water piping shall be brazed with AWS classification BCuP-2 brazing alloy.	

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D.	At the Contractor's option, piping 2" and smaller for service to 300 psig may be Schedule 5S A312, grade 304L stainless steel approved for use with the Vic-Press 304™ fittings or A 312 grade 304 stainless steel approved for use with the Viega ProPress 304 FXM Fittings, in strict accordance with the product listings and installation guidelines.													
E.	Carbon Steel Pipe 5" and larger shall be ASTM A 53 Grade B ERW or Seamless black pipe manufactured [in the United States] by a pipe mill that holds an in-force American Petroleum Institute license [and can be of domestic or foreign origin] ERW pipe must be heat treated to a minimum of 1,000°F such that the seams are annealed and there is no un-tempered martensite. Each piece of pipe shall bear the mill name or mark, the specification, the grade, the method of production (type), the size/wall, the country of origin and the applicable heat number. All pipe delivered to the job shall be accompanied by the applicable Mill Test Certificate, which shall correlate with stenciled information on the pipe. If pipe is cut into smaller pieces by the contractor then the mill name and heat number must be transferred to the cut piece. [All piping shall be subject to the restrictions specified herein in Part 3 - Execution. Pipe manufactured in the Peoples Republic of China is not allowed.]													
F.	Steel pipe thickness shall be in accordance with ANSI B36.10, current edition and shall be as follows, except all weld fittings shall match the thickness of the pipe to which they are connected:													
	1. For 150 psig, and 300 psig:													
	<table border="0"> <tr> <td>a.</td> <td>Up to 10"</td> <td>-</td> <td>Standard or Schedule 40</td> </tr> <tr> <td>b.</td> <td>12" and larger</td> <td>-</td> <td>0.375" minimum wall thickness</td> </tr> </table>	a.	Up to 10"	-	Standard or Schedule 40	b.	12" and larger	-	0.375" minimum wall thickness					
a.	Up to 10"	-	Standard or Schedule 40											
b.	12" and larger	-	0.375" minimum wall thickness											
	2. For 400 psig:													
	<table border="0"> <tr> <td>a.</td> <td>Up to 10"</td> <td>-</td> <td>Standard or Schedule 40</td> </tr> <tr> <td>b.</td> <td>12" through 18"</td> <td>-</td> <td>0.375" minimum wall thickness</td> </tr> <tr> <td>c.</td> <td>20" through 24"</td> <td>-</td> <td>0.500" minimum wall thickness</td> </tr> </table>	a.	Up to 10"	-	Standard or Schedule 40	b.	12" through 18"	-	0.375" minimum wall thickness	c.	20" through 24"	-	0.500" minimum wall thickness	
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b.	12" through 18"	-	0.375" minimum wall thickness											
c.	20" through 24"	-	0.500" minimum wall thickness											
G.	Steel piping systems shall be butt-welded construction in strict accordance with Chapter 5 of ANSI B31.9, except in locations where flanges or grooved couplings are required for servicing and/or removal of equipment for repair, etc. Screwed unions may be installed, instead of flanged fittings for sizes 3" IPS and smaller. Flanged and screwed joints shall be accessible for repair. Screwed or flanged fittings shall not be permitted in inaccessible furred ceilings or chases. Copper piping systems shall be brazed with AWS classification BCuP-2 brazing alloy as required by system working pressure and temperature.													
H.	Fitting material shall be as follows:													
	<table border="0"> <tr> <td>1.</td> <td>Pipe fittings for 150 psig working pressure systems, 2-1/2" and smaller, where permitted, shall be Class 150, ANSI B16.3 screwed malleable iron or Viega MegaPress/ProPress press-connect fittings. Other fittings shall be welded fittings, ANSI B16.9 with wall thickness and material identical to installed pipe. Flanges where specified and/or required, shall be Class 150, ANSI B16.5, forged steel, screwed or welding neck type as required.</td> </tr> <tr> <td>2.</td> <td>Pipe fittings for 300 and 400 psig working pressure systems, 2-1/2" and smaller, where permitted, shall be Class 300, ANSI B16.3 screwed malleable iron. Other fittings shall be welded fittings, ANSI B16.9 with wall thickness and material identical to installed pipe.</td> </tr> </table>	1.	Pipe fittings for 150 psig working pressure systems, 2-1/2" and smaller, where permitted, shall be Class 150, ANSI B16.3 screwed malleable iron or Viega MegaPress/ProPress press-connect fittings. Other fittings shall be welded fittings, ANSI B16.9 with wall thickness and material identical to installed pipe. Flanges where specified and/or required, shall be Class 150, ANSI B16.5, forged steel, screwed or welding neck type as required.	2.	Pipe fittings for 300 and 400 psig working pressure systems, 2-1/2" and smaller, where permitted, shall be Class 300, ANSI B16.3 screwed malleable iron. Other fittings shall be welded fittings, ANSI B16.9 with wall thickness and material identical to installed pipe.									
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		Flanges where specified and/or required, shall be Class 300, ANSI B16.5, forged steel, screwed or welding neck type as required.
3.		<p>Copper pipe fittings and accessories for chilled water and heating hot water for 150 psig and 300 psig working pressure systems 2" and smaller shall be as follows:</p> <ol style="list-style-type: none"> Copper tube fittings shall be wrought copper joint fittings conforming to the latest edition of ANSI B16.22. suitable for the working pressure of the system. All brazed fittings shall be brazed with AWS classification BCuP-2 brazing alloy as required by the system temperature and working pressure. Press-connect fittings with EPDM or FKM seals, manufactured by Viega and installed with a RIDGID ProPress crimping tool may be used in lieu of brazed fittings.
4.		<p>Weld fittings shall be factory made and shall be full line size. For branch pipes more than one size smaller than the diameter of the main pipe, ANSI B16.9 integrally reinforced branchlets, may be used. Shaped nipple welding fittings with factory beveled ends may be used at the Subcontractor's option for branch sizes 3" and smaller with working pressures up to 150 psig. Shaped nipples shop fabricated with patterns and assembled in the shop will be acceptable. "Weldolets" and "Threadolets" fittings and shaped nipples shall have a wall thickness as required by the ANSI B31.1.0 and ANSI 31.9 Code and shall be suitable for the working pressure and temperature of the pipe to which they connect. No branch shall be made by burning a hole in the main and welding in the branch line.</p>
5.		<p>At each joint the flanges shall have matching flat faces or raised faces and the flanges shall be identical in configuration and pressure rating. Steel flanges shall have a minimum tool finish. When 150 lb. steel flanges are connected to 125 lb. cast iron flanged valves or fittings, the steel flanges shall be flat face medium finish.</p>
6.		<p>Screw joints shall be made up with pipe joint compound. Screw threads shall be in accordance with American Pipe Thread Standards.</p>
7.		<p>Gasket material shall be as specified herein and shall be suitable for the service and pressure class intended.</p> <ol style="list-style-type: none"> Gaskets shall be 1/16" thick for all pipe sizes 10" and smaller and 1/8" thick for all pipe sizes 12" and larger. Gaskets shall be ring type between raised face flanges and full-face type between flat face flanges with punched bolt holes and pipe opening. Gaskets shall be J. M. Clipper Style 960 or 961 compressed nonasbestos with a nonstick clean surface and factory applied parting agent applied to both sides of the gasket. Gaskets shall contain no asbestos.
8.		<p>Flange bolting materials for flanges where the pressure does not exceed 400 psig (water) shall be carbon steel ASTM A 307 Grade A hexagon head bolts and hexagonal nuts. Furnish Grade A bolts for flanged joints in piping systems where one or both flanges are cast iron. Cap screws utilized with flanged butterfly valves shall be ASTM A 307 Grade A cap screws with hexagon heads. Flange bolt thread lubricant shall be an antiseize compound designed for temperatures up to 1000°F. Where the configuration or arrangement of flanged fittings prevents the use of machine bolts, stud bolts shall be used.</p>
9.		<p>At the Contractor's option, piping 2" and smaller for 150 and 300 psig working pressures may be Vic-Press 304™. Pipe to be approved for use with the Vic-Press 304™ system.</p>

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	<ul style="list-style-type: none"> a. For Fittings and Couplings: Precision cold drawn austenitic 304 stainless steel supplied with synthetic rubber O-ring. b. For Unions: Precision cold drawn austenitic 304 stainless steel supplied with synthetic O-ring, with threaded union, equal to Victaulic Style 584, or plain end pipe with one grooved couplings, equal to Victaulic Style 547. c. For Flanges: Precision cold drawn austenitic 304 stainless steel supplied with synthetic O-ring, with carbon steel back-up flange, Victaulic Style 565. d. Tool: Tool to be supplied by Victaulic, PFT501, PFT505, or PFT507. 	
10.	<p>If the capability of the Subcontractor is demonstrated to the Engineer, at the Subcontractor's option, and as approved by the authorities having jurisdiction, grooved couplings and fittings may be used for 150 and 300 psig working pressure pipe sizes 24" and smaller in lieu of welded or screwed joints as specified herein.</p> <ul style="list-style-type: none"> a. Piping: <ul style="list-style-type: none"> 1) 2" through 8" sizes: Victaulic Style 107 "QuickVic," Gruvlok 7401, 7402 or equal UL listed painted ductile iron couplings with cut groove or roll groove may be used subject to the Special Requirements herein. 2) 10" through 12" sizes: Victaulic Style 07 "Zero Flex," Gruvlok 7401, 7402 or equal UL listed painted ductile iron couplings with cut groove or roll groove may be used subject to the Special Requirements herein. 3) 14" through 24": Two (2) segment couplings shall have a wide key profile, flat bolt pads and lead-in chamfer on each coupling segment to allow for uniform tightening of the joint. Gaskets shall be wide, pressure responsive suitable for temperatures associated with the application. Victaulic Style W07 rigid and Style W77 flexible or Guvlok 7401, 7001 or equals shall be used. b. Victaulic Style 177 "QuickVic" (2" through 6"), Victaulic Style 77 (8" through 12"), Gruvlok 7000 or equal couplings with cut or roll groove may be used in association with spring isolated systems as described in Section 23 05 48 titled "Vibration and Seismic Controls for HVAC Piping & Equipment", subject to the Special Requirements herein. c. For Fittings: Victaulic or equal UL listed galvanized or painted ductile iron full flow fittings and Style 920/920N or Gruvlok 7045/7046 mechanical tees with cut or roll groove suitable for the design working pressures specified in the paragraph titled "Design Conditions" in Section 23 05 00 may be used subject to the Special Requirements in Subsection 2.03F.9. e. herein. d. For Flanges: Flange adapters shall be equal to Victaulic Style 741 or Style 743 or Gruvlok 7012, 7084. UL listed, galvanized or painted, ductile iron, with electroplated steel hinge bushings. e. For Strainers: Victaulic Style 732 or Gruvlok 758G, 768 G or or equal UL listed galvanized or painted ductile iron strainers with groove suitable for the design working pressure specified in the paragraph titled "Design Conditions" in Section 23 05 00 may be used subject to the Special Requirements in specified below. f. Special Requirements: Victaulic, Gruvlok or equal full flow fittings and couplings shall be made of ASTM A-395 Grade 65-45-15, A-536 Grade 65-45-12 ASTM A-536 Grade 65-45-12 ductile iron or ASTM A-53, Grade B steel with grooved ends. 	

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g. Gaskets for water service below 230°F shall be "Triple Seal" Grade E synthetic, supplied by the manufacturer with dry lubricant to facilitate installation. Couplings shall be provided with heat treated zinc or cadmium plated steel bolts and units. Grooved piping system manufacturer shall be ISO 9001 approved.

- I. A cut or roll groove machine shall be used for all grooves in piping. The coupling and fitting manufacturer shall provide a certified letter with the Shop Drawing stating that the Subcontractor's roll or cut grooving machine and the couplings and fittings utilized on this Project will provide a system complying with the pressure class and piping materials previously specified. A cut groove depth control tool shall be used for field and shop grooving of piping. A hole cutting tool shall be used in lieu of burning a hole in the piping. When using joining materials the piping shall be installed in accordance with the joint manufacturers written instructions. Gaskets shall be UL listed for the service and working pressure of the systems. The manufacturer shall provide a training class to Subcontractor's personnel involved in installing all systems 12" diameter and larger. After the installation is complete, the manufacturer's factory technician shall inspect all couplings 12" diameter and larger and verify to the Engineer in writing the installation is in accordance with the manufacturer's published installation instructions. Reducing couplings and outlet couplings shall not be allowed. Couplings and fittings installed throughout the Project shall be the product of one manufacturer.
- J. At the Subcontractor's option, factory built piping assemblies containing such items as stop valves, strainers, manual balancing valves, flow control devices, automatic control valves, pressure temperature test ports, etc., will be acceptable. Automatic controls valves shall be coordinated with the Division 25 Contractor and shall meet any control valve specifications in Division 25. The individual components of the factory built piping assembly shall comply with the requirements specified herein.

2.3 CHILLED WATER AND HEATING HOT WATER PIPING (BELOW GROUND)

- A. Underground chilled water piping shall be pre-insulated and pre-fabricated piping system.
1. Carrier Pipe and Fittings: Carrier pipe shall be as specified for "Chilled and Condenser Water Piping (Above Ground)".
 2. Pipe thickness for underground chilled water piping shall be in accordance with ANSI B36.10, current edition, and shall be as follows:
 - a. ¾" through 2" Extra Heavy or Schedule 80
 - b. 2½ " through 10 "Schedule 40
 - c. 12" through 18" Standard Weight
 - d. 20" through 30" Extra Heavy
 - e. 36" through 42" Schedule 30
- B. Insulation:
1. Below ground service pipe insulation shall be 2-pound nominal per cubic foot density, polyurethane or polyisocyanurate, K-factor of 0.17 @ 75°F in nominal density, inch conformance with ASTM C-591 and ASTC-591, completely fill the annular space between the carrier pipe jacketing, for straight section and pre-formed polyurethane foam for fittings.
 2. To ensure no voids are present, all insulation shall be inspected by one of the following three (3) methods: visually checked prior to application of the protective jacket; infrared

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	inspection of the entire length; or x-ray inspection of the entire length. The insulation shall be applied to 2" minimum thickness.	
	3. At the Contractor's option, cellular glass insulation with a K-factor of 0.29 at 75°F may be used provided that the thickness installed results in an equivalent thermal performance of that listed hereinabove.	
	C. Factory Fabrication of Fittings:	
	1. All fittings will be factory prefabricated and insulated at pre-insulators plant. No insulation of fittings will be allowed at the job site. Jacket material and thickness shall be as specified for pipe. Jacket fittings which are mitered shall be butt fusion welded to provide water tight seal.	
	2. All piping materials, fabrication, erection, flanging, welding, tests, etc., shall be in accordance with American National Standard Code for Pressure Piping, Current edition. Wire type "Short Arc" welding machines will not be acceptable for field welds, except where "shop procedures and methods" can be maintained for prefabrication of piping systems, subject to the approval of the Designer. Wire type short arc welding machines will be acceptable for shop fabricated piping. If in the opinion of the Engineer, any "short-arc" weld is found unsatisfactory, the use of the wire type short welding machine shall be discontinued for all remaining welding and re-welding of the defective welds. The Engineer and the Owner shall have unrestricted access, at all times during normal working hours, to the pipe fabrication facilities.	
	3. All welders shall be certified by ANSI B31.9 "Standard Qualification Welding Procedures, Welders and Welding Operators" or "Qualification Tests" in Section IX ASME Boiler and Pressure Vessel Code. Furnish welder performance qualification test certificates for positions 2G, 5G or 6G made in strict compliance with the above codes. Welders shall be certified for the type of pipe material specified. All costs incident to procedures and welder's qualification tests shall be assumed by the manufacturer. Two (2) copies of the qualification test report and certification with welder's identification commences by the welder. Each weld shall bear the welder's identification mark permanently indented in the weld. Welding procedures shall also be in accordance with the requirements of the American Welding Society, current edition, where applicable.	
	D. Protective Jacket: All insulated pipe will be jacketed with either seamless, extruded, black high density polyethylene (HDPE) manufactured in accordance with ASTM D-1248, that is pressure tested to insure water tightness, having minimum wall thicknesses as follows: Through 12.85" - .150 inches; from 13.59 to 18.22 inches - .200 inches; from 19.09 inches to 28.25 inches - .250 inches; from 30.28 inches to 38.47 inches - .300 inches; from 40 inch to 48 inch - .375 inches or FRP (fiberglass) having a minimum wall thickness of 160 mils for 20 inch carrier pipe and 200 mils for 30 inch carrier pipe.	
	E. Field Joint Insulation: After welding and testing of carrier pipe, the straight coupling joints shall be insulated with polyurethane foam. The foam shall be poured into a wrap around, split HDPE or FRP sleeve. After the foam has cured, the entire sleeve will be jacketed with an adhesive backed, heat shrinkable, irradiated polyethylene sleeve to make the field joint watertight. Field joints will be insulated per the manufacturer's recommendations with materials furnished by the manufacturer.	
	F. Temporary Field Joint Protection: See Drawings for temporary field joint protection.	

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G.	Anchors (If Required): ½" thick steel prefabricated anchor plate shall be factory welded to the carrier pipe and placed at locations shown on the Drawings. A concrete anchor block will be poured in the field by the Contractor at all anchor locations.	
H.	Insulation End Seals and Pipe End Covers: Each pipe or fitting end shall be sealed watertight by use of a polyethylene shrink end seal to prevent the egress of moisture into the insulation. In addition, cover all open pipe and fitting ends with plastic caps taped to the pipe and/or fitting.	
I.	<p>Installation:</p> <ol style="list-style-type: none"> <li>1. The installation shall be made in strict accordance with the Drawings and Specifications, and manufacturer's installation instruction. The manufacturer will provide a field instructor on site to train Contractor's personnel in all phases of installation and provide periodic reviews of the installation to ensure compliance with the installation procedures. A written report of each field service visit shall be sent to the Engineer and all other parties designated by the Engineer. <li>2. The system manufacturer shall perform a complete stress analysis on the system to determine anticipated thermal movement in the carrier pipe and to determine required anchorage, etc. Provide anchors as required by the stress analysis. Factory trained field supervision shall be provided for critical periods of installation such as unloading, field joint instruction, testing and backfilling. The entire installation shall be in strict accordance with the manufacturer's instructions and recommendations. 	

2.4 DRAIN PIPING

- A. Drain piping from each air handling unit drain pan, heat exchanger, pump base drains, tank and vessel overflows, auxiliary drain pans, piping system drains, blow downs and strainers (not less than 2"), shall be extended to the nearest floor drain, hub drain or condensate drainage system, except in the central mechanical plant. In the central mechanical plant all drains on water chilling units, heat exchangers, strainers, piping systems, etc., shall be equipped with full bore ball valves and full size quick disconnect type couplings with caps for drains 1" and larger and hose end adapters for smaller drains. At the contractor's option, ½" and ¾" drain valves with integral nose cap and chain similar to Nibco T&S-585-70-HC or Kitz 68C will be acceptable. Drains shall be of the sizes indicated but not less than the full size of the drain pan, strainer or equipment connection. Air handling unit drains shall have deep seal traps to permit unit pan drainage under normal unit operation and complete drainage of the pan upon unit shutdown. A deep seal trap shall be installed for each blow through or draw through air handling unit to maintain the water seal.
- B. Drain piping shall be Schedule 40 ASTM A 53 galvanized steel pipe with Class 150 ANSI B16.3 galvanized malleable iron fittings or Type "K" or "L" copper pipe with wrought copper fittings.

2.5 STEAM SUPPLY AND CONDENSATE RETURN PIPING AND VALVES

- A. This building will utilize one pressure class for steam piping systems and one pressure class for condensate piping systems. Pipe, valves and fittings shall conform to requirements of 150 psig working pressure.
- B. Piping shall be black steel. The materials shall be seamless or electric resistance welded ASTM A-53 carbon steel for sizes 2-1/2" and smaller. Piping larger than 2-1/2" shall be seamless or

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electric resistance welded, A-53, Grade A or B. Electric resistance welded pipe shall be fully normalized in the area of the weld. Pipe thickness shall be in accordance with ANSI B36.10, current edition as follows. For 150 psig working pressure systems:

1. Steam Supply - All Sizes - Schedule 40 (standard weight).
 2. Condensate Return - All Sizes - Schedule 80 (extra heavy).
- C. Piping systems shall be of butt-welded construction in strict accordance with Chapter 5 of ANSI B31.9, except in locations where flanges shall be required for servicing and/or removal of equipment for repair, etc. Screwed fittings shall be permitted in lieu of flanged fittings for sizes 2" IPS and smaller. Flanged and screwed joints shall be accessible for repair. Screwed or flanged fittings shall not be permitted in furred ceilings or chases.
- D. Fitting material shall be as follows:
1. Pipe fittings for 150 psig working pressure systems, 2" and smaller, where permitted, shall be cast iron. Other fittings shall be welded fittings, ANSI B16.9 with wall thickness identical to pipe in which installed. Flanges, where specified and/or required, Class 150 ANSI B16.5, raised face, forged steel, screwed or welding neck type as required.
 2. Welded fittings shall be factory made and shall be used full line size, except as otherwise specified herein, with reducers after the fittings, if required. For branch pipes less than one size smaller than the diameter of the main pipe, ANSI B16.9 fittings may be used. "Weldolets" or "Threadolets" shall have the same schedule or pressure standard as the pipe to which they connect. No branch shall be made by burning a hole in the main and welding in the branch line or by using a "saddle" type fitting.
 3. At each joint the flanges shall have matching flat faces or raised faces and the flanges shall be identical in configuration and pressure rating. Steel flanges shall have a medium tool finish and shall have either flat or raised faces. When 150 lb. steel flanges are connected to 125 lb. cast iron flanged valves or fittings, the steel flange shall have flat face medium finish.
 4. Screw joints shall be made up with approved equal pipe joint compound. Screw threads shall be in accordance with American Pipe Thread Standards.
 5. Gasket material shall be as specified herein and shall be suitable for the service and pressure class intended:
 - a. Gaskets for cast iron flanges shall be 1/16" thick full face non-asbestos composition gaskets for flat face flanges and flat ring non-asbestos gaskets for raised face flanges with punched bolt holes.
 - b. Gaskets for steel flanges shall be 1/16" thick flat non-asbestos composition gaskets for all pipe sizes 10" and smaller and 1/8" thick flat ring non-asbestos composition gaskets for all pipe sizes 12" and larger with punched bolt holes and pipe opening.
 6. Flange bolting materials for flanges in service at 399°F or below shall be carbon steel ASTM A-307 Grade B hexagon head bolts and nuts. Flange bolt thread lubricant shall be an antiseize compound.
- E. Steam and condensate piping fabrication and installation shall be as specified herein in Subsection 3.01 titled "General" and as follows:

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1.	Welding and fabrication coming under the jurisdiction of the ASME Boiler and Pressure Vessel Code shall be performed in conformance with that code.	
2.	All steam supply and condensate return piping shall be arranged for a uniform slope toward drips and condensate return lines shall grade uniformly toward the condensate receiver. All piping shall be well graded in the proper direction with a 1" fall for each 20'-0" run.	
3.	All equipment supplied with steam shall have the steam return lower than the equipment and shall have gravity drain where possible. At locations where this cannot be accomplished, special precautions shall be taken to obtain removal of air and condensate. Each such case shall be subject to the approval of the Architect.	
4.	All steam condensate underground piping shall be stainless steel and shall be coated and protected as follows:	
	<ul style="list-style-type: none"> a. All underground steam pipe shall have all exterior surface coated with Republic Steel Corporation's X-Tru-Coat high density polyethylene extruded coating. b. The protective coating shall be factory applied with a fluid mastic undercoat. The polyethylene coating shall be a minimum of 0.040 inches thick. Protective coating may be factory applied by Standard Pipe Protection Division of General Steel Industries, Inc. c. Field welds, joints and fittings shall be protected with mastic undercoat and by wrapping with at least two (2) layers (half lap) of "X-Tru-Tape" installed as recommended by the manufacturer or with Raychem "Thermofit" heat shrinkable pipe sleeves applied as recommended by the manufacturer. 	
F.	Steam Traps:	
1.	Steam condensate traps shall be inverted bucket or float and thermostatic type, as specified herein and indicated on the Drawings. 150 psig system traps, steam main drip traps and end of main traps shall be inverted bucket type.	
2.	Steam condensate traps shall be adequate for the system operating temperatures and pressure. Steam traps shall be sized with the following safety factors at the maximum condensate load condition and the minimum pressure differential available for removing condensate.	
	<ul style="list-style-type: none"> a. Hot Water Heat Exchangers: 2 to 1 b. Steam Main Drips: 2 to 1 c. Steam Main to Reducing Valves: 3 to 1 d. End of Main Drips: 3 to 1 	
3.	Inverted bucket traps shall have cast iron body with valves and seats of heat treated chrome steel. All working parts shall be constructed of stainless steel. Traps shall have integral strainers or inlet Y Type strainers complete with blow down valves.	
4.	Float and thermostatic type traps shall have cap and body of ASTM A-278 Class 30 cast iron. Float and mechanism shall be stainless steel with heat treated chrome steel valve. Thermostatic air vent element shall be a charged multi-convolution beryllium copper elbows caged in stainless steel.	
5.	Steam trap installation shall be complete with inlet strainer and blow down valves and piping conforming to the working pressure and temperature of the line the trap serves.	
6.	If it complies with these Specifications, one of the following manufacturers will be acceptable: Armstrong, McDaniel, Sarco or Watson.	

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G. Strainers:

1. Steam and condensate strainers shall be similar and approved equal to the following Mueller Steam Specialty Company model numbers listed.
 - a. 150 psig steam working pressure - 2" through 12", Muessco No. 751 flanged type, iron body and stainless-steel screen with 3/64 inch perforations.
 - b. 150 psig steam working pressure - up to 2", Muessco No. 11 with iron body, screwed ends and 30 mesh stainless steel screens.

H. Vacuum Breakers: Steam vacuum breakers shall be a 1" swing check valve similar and approved equal to a Crane No. 137 with cast bronze body, cap and disc. Valves shall be suitable for the steam pressures and temperatures listed in the paragraph titled "Design Conditions" in Section 23 05 00.

I. Steam Pressure Reducing Valves:

1. Steam pressure reducing valves shall be self-contained pilot operated Spence Type "E" with full port valve or approved equal and shall have the minimum capacities and requirements specified in the "Schedule of Capacities" on the Contract Documents.
2. Steam, pressure reducing valve and pilot valve shall have cast iron bodies, hardened stainless steel valve plug and seat ring and stainless-steel diaphragm, with top and bottom guides.
3. The valve shall be suitable for the steam working pressures as listed in the paragraph titled "Design Conditions" in Section 23 05 00.

J. Steam and Condensate Valves

1. Furnish and install all steam and condensate valves that are shown on the Drawings and/or specified herein. Packing and gaskets shall contain no asbestos and shall be so certified. See Section 23 05 00 for certification requirements. Prior to purchase of any valve manufactured outside the United States, the Subcontractor shall submit complete construction details, material list of all components, pressure test data and certified compliance with the reference standards listed herein.
2. Stop valves in steam and condensate service shall be bronze or cast-iron gate valves with rising or non-rising stems 2" and smaller with temperature and pressure ratings suitable for the specified service. Gate valves 2" and larger shall be outside screw and yoke flanged type. Provide chain operators with chain cleats for all valves located 10'-0" above the floor. At the Subcontractors option stop valves 3" and larger may be high performance full lug body carbon steel butterfly valves specifically designed for steam service for on-off operations and ANSI Class 150 service. Furnish gear operators on all steam service butterfly valves.
3. Throttling type valves in steam service shall be globe type valves. Valves 2" and smaller shall have bronze or cast-iron bodies with temperature and pressure ratings suitable for the specified service. Globe valves 2 1/2" and larger shall be flanged type with cast iron bodies. Provide chain operators with chain cleats for all valves located 10'-0" above the floor.
4. Bypasses for ease in closing shall be provided for all 12-inch and larger stop valves regardless of pressure classification. Bypasses shall be sized in accordance with the manufacturer's recommendations. Bypasses on valves 150 psi class and heavier shall be of the three-valve type with one valve to serve as vent between the other two valves.

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2.6 CONTROLLING WATER VALVES

- A. Furnish and install all valves that are shown on the Drawings and/or specified herein. Packing and gaskets shall contain no asbestos and shall be so certified. See Section 23 05 00 for certification requirements. Prior to purchase of any valve manufactured outside the United States the Subcontractor shall submit complete construction details, material list of all components, pressure test data and certified compliance with the reference standards listed herein.

- B. Chilled, Heating Hot Water and Condenser Water Valves:
 - 1. All chilled, heating hot water and condenser water valves shall be in accordance with the following:
 - a. General:
 - 1) Characterized ball valves shall be constructed to permit repacking without removal of the valve body from the line and stem shall not blow out under pressure. Valves used for chilled water service shall be insulated and vapor sealed to the protective sleeve around the stem to maintain the integrity of the chilled water piping insulation as detailed on the Drawings. Extended, non-thermal conductive handle characterized ball valves shall be utilized. The characterized ball valve stem shall be extended so that the operating handle is above the pipe insulation surface. All valves utilized for tenant connections on chilled or condenser water risers shall have factory handles.
 - 2) Characterized ball valves for 2" and under service on Vic-Press 304™ piping systems shall be supplied with Pressfit® ends, equal to Victaulic Series 589. At the Contractor's option, if a grooved coupling and fitting system is provided as specified herein, Victaulic Series 726 or Gruvlok 7500 grooved end ductile iron characterized ball valve may be provided.
 - 3) Pressure Independent Temperature Control Valves (PICV) shall be utilized for all hydronic system temperature control and balancing requirements. The PICV valves shall conform to the requirements as listed in Division 23, Section 2.7 below.
 - 4) Butterfly valves 2-1/2" through 5" in size shall have lever multi-position position (throttling) type operators with memory stop and position lock. For valves 6" and larger, operators shall be enclosed self-locking worm gear type, waterproof and factory lubricated. Operator shall have built in position indicators. Provide chain operators with chain cleats for all valves located more than 10'-0" above the floor. Manufacturer shall certify compliance with bubble tight shutoff requirements at full rated design pressure when flanged and at a differential pressure not less than the design working pressure and temperature specified with the downstream flange removed with flow in either direction. Butterfly valves installed in horizontal piping shall be mounted with the stem in the horizontal position and rotation so that the bottom of the disc lifts in the direction of flow.
 - 5) At the Contractor's option, if a grooved coupling and fitting system is provided as specified herein, Victaulic VIC-300 or Gruvlok 7700 series butterfly valves 2 1/2" through 4" with EPDM encapsulated or nickel-coated ductile iron disc and PPS or black enamel inner wall coating may be used.

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	<ul style="list-style-type: none"> 6) At the Contractor's option, for 14" through 24" piping, if the grooved coupling and fitting system is provided as specified here, Victaulic Series Vic-300 AGS (for service to 300 psig) with PPS coated body and disc, with elastomer seal may be used. 7) Valves with special seats to meet temperature requirements shall have special markings clearly identified on the Shop Drawings. 8) Check valves, strainers, etc., shall be as specified herein under Subsection titled "Miscellaneous Piping Accessories". 9) All controlling valves shall have a valve authority between 0.2" and 0.5". 	
b.	150 Psig Working Pressure, Above Ground (Chilled, Heating Hot Water and Condenser Water):	
	<ul style="list-style-type: none"> 1) Stop valves for insulated piping systems up to and including 2 ½" shall be full port ball valves, with extended non- thermal conductive handles. Ball valves for non-insulated condenser water piping shall be full port, bronze body (ASTM B-584, B-62 or B-61) valves. Ball valves shall be cast bronze or ASTM approved alloy with stainless steel or nickel-chromium plated ball and stem, 600 psig non-shock WOG at 200°F. Valve shall have a stem extension of sufficient length to position the operating handle, protective sleeve to maintain integrity of piping insulation, mechanical memory and position lock devices above the insulation. 2) Ball valves 2" and smaller, for 150 psig service on Vic-Press™ systems shall be Victaulic Series 589 standard port ball valves, cast brass body, chrome plated brass ball and stem, TFE seat and stem washer, with 304 stainless steel ends complete with elastomer O-rings. 3) Elastomer seated stop valves 3" and larger shall be butterfly type, 150 psig non-shock WOG at 200°F, ANSI Class 125/150 flanges with full tapped and threaded lugs and ductile iron body. The resilient elastomer seat shall be field replaceable and suitable for the service intended. Disc shall be fabricated from aluminum bronze, manganese bronze, stainless steel or Nylon II coated ductile iron and the shaft shall be fabricated from 416, 316 or 17-4 PH stainless steel. Provide seals at the top and bottom of the upper and lower shafts so that there will be guaranteed zero leakage to the shaft. 4) At the Contractor's option, factory built piping assemblies containing such items as ball valves, strainers, flow control devices, automatic control valves (PICV's), pressure/temperature test ports, etc. will be acceptable. The individual components shall comply with the specifications herein. All automatic control valves (PICV's) within the factory built flow assembly shall have unions on both sides for ease of removal. 5) Stop valves for 150 psig service 2½" and larger in grooved piping systems shall be butterfly type, with grooved ends PPS or black enamel coated ductile iron body. Disc to be ductile iron, fully elastomer encapsulated, with Naval brass upper bearing and lower trunnion or type 416 stainless steel two-piece stem. Seals to be of the same elastomer as the disc coating. 6) Stop valves for 300 psig service 14" through 24" in grooved piping systems shall be Victaulic Vic-300 AGS butterfly type, with grooved end PPS coated ductile iron body and disc, elastomer seal, reinforced PTFE bearing, 17-4 PH stainless steel stem and disc driving pin. 	

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c.	150 PSIG Working Pressure, Below Ground (Chilled Water): Below ground chilled water valves shall be flanged Class 250 butterfly valve, as follows:	
	<ol style="list-style-type: none"> 1) Valve bodies shall be constructed of cast iron ASTM A-12B Class B. End connections shall be flanged. 2) Valve discs shall be made from cast iron ASTM A-126, Class B or ductile iron ASTM A-536. discs shall be furnished with 316 stainless steel seating edge to mate with the rubber seat. 3) Valve seat shall be Buna-N rubber located on the valve body. 4) Valve shafts shall be stainless steel ASTM A-564 Type 630 Condition H-1100. Stub shafts or through shafts are acceptable. 5) Shaft seals shall be standard self-adjusting split V packing. Shaft seals shall be of a design allowing replacement without removing the valve shaft. 6) Valve bearings shall be sleeve type that are corrosion resistant and self-lubricating. 7) Valve actuators shall be right angle, fully greased packaged and have stops in the open/close position. The actuator shall have a mechanical stop which will withstand an input torque of 450 ft. lbs. against the stop. The traveling nut shall engage alignment grooves in the housing. The actuators shall have a built-in packing leak bypass to eliminate possible leakage into the actuator housing. 8) The valve interior and exterior surfaces, except for seating, shall be coated with two (2) coats of asphalt varnish in accordance with TT-C-494A and AWWA C04 latest edition. 9) All valves shall be hydrostatic and leak tested. The leak test shall be performed at a differential pressure of 250 psig with the disc in a closed position. In a slightly open position, internal hydrostatic pressure equal to 500 psi shall be applied to the inside of the valve body for five (5) minutes. 	
d.	Condenser water hot tap valves shall be US Pipe Smith Metropolitan horizontal, non-rising stem, flanged gate valve, Series 300, right angle beveled gear, without bypass, 150 psi WWP, 300 psi test pressure. Provide US Pipe Figure 100 N.R.S. floor stand with indicator and shaft between floor stand and valve.	
e.	300 and 400 Psig Working Pressure (Chilled, Heating Hot Water and Condenser Water):	
	<ol style="list-style-type: none"> 1) Stop valves for insulated piping systems up to and including 2 ½" shall be full port ball valves, with extended non-thermal conductive handles. Ball valves for non-insulated condenser water piping shall be full port valves. Ball valves shall be cast bronze or ASTM approved alloy with, stainless steel ball and stem, 600 psig non-shock WOG at 200°F. Valves shall have a stem extension of sufficient length to position the operating handle, mechanical memory and position lock devices above the insulation. A protective sleeve integral to the valve around the stem shall be provided to maintain the integrity of the chilled water piping insulation. Refer to the Detail on the Drawings. Packing and gaskets shall be Teflon. 2) Ball valves 2" and smaller, for 300 psig service on Vic-Press 304™ systems shall be Victaulic Series 589 standard port ball valves, cast brass body, chrome plated brass ball and stem, TFE seat and stem washer, with 304 stainless steel ends complete with elastomer O-rings. 	

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- 3) High performance offset shaft type butterfly stop valves 3" and larger shall be 720 psig non-shock WOG, ANSI Class 300 compatible with ANSI B16.5 flanges, full tapped and threaded steel lug body. Valves shall have 300# body drilling and shall be suitable for service intended. Stop valves shall be suitable for bi-directional zero leakage dead end service to the fully rated pressure with either the downstream or the upstream flange removed to the fully rated pressure. Disc shall be fabricated from stainless steel and the shaft shall be fabricated from 316, 416 or 17-4 pH stainless steel and have the eccentric double or triple off-set design. Provide adjustable PTFE stem seals as required so that there will be guaranteed zero leakage. Seats and backing rings shall be PTFE or RPTFE. The seat assembly shall be locked in the body recess by a full-face seat retainer. Bearings shall be constructed of stainless steel/PTFE. Seat retainer ring fasteners shall be a non-wetted part.
- 4) At the Contractor's option, 2-1/2" and smaller factory built flow assemblies for manual water balancing containing such items as ball valves, butterfly valves, strainers, flow control devices, automatic control valves (PICV's), pressure/temperature test ports, etc. The individual components shall comply with the specifications herein. All automatic control valves within the factory built flow assembly shall have unions, flanges, or grooved ends on both sides for ease of removal. Automatic control valves shall be coordinated with the Division 25 Contractor and shall meet any control valve specifications in Division 23, Section 2.7 Below.
- 5) Stop valves for 300 psig service 2½ " and larger in grooved piping systems shall be butterfly type, with grooved end PPS or black enamel coated ductile iron body. Disc to be ductile iron, fully elastomer encapsulated, with Naval brass upper bearing and lower trunnion or type 416 stainless steel two-piece stem. Seals to be of the same elastomer as the disc coating. If it complies with these Specifications, valves shall be manufactured by Victaulic or Gruvlok.
- 6) Stop valves for 300 psig service 14" through 24" in grooved piping systems shall be Victaulic Vic-300 AGS butterfly type, with grooved end PPS coated ductile iron body and disc, elastomer seal, reinforced PTFE bearing, 17-4 PH stainless steel stem and disc driving pin.

2.7 PRESSURE INDEPENDENT TEMPERATURE CONTROL (PICV) & BALANCING VALVES

A. Control Valves: Factory fabricated pressure independent with internal differential pressure regulator (DPRV) which automatically adjusts to normal changes in system pressure and provides 100 percent control valve authority at all positions of the valve; maintain proportional/linear flow coil characteristics; and maintain a liner flow characteristic. The PICV shall accurately control the flow from 0-100 percent full rated flow with an operating pressure differential range of 3 to 60 psig, FCI 70-2 Class 4 shut-off on all sizes and field serviceable. Control valve shall incorporate control, balancing and flow limiting. Hydronic system pressure independent control valve bodies shall meet ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure and shall have the following characteristics:

1. NPS 2 and Smaller: Class 150 bronze or brass body with union connections, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, and screwed ends with back seating capacity repackable under pressure.

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	<ol style="list-style-type: none"> 2. NPS 2-1/2 and Larger: Class 125 iron or ductile iron body, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, flanged ends with back seating capacity repackable under pressure. 3. Pressure Control Seat: Brass construction with vulcanized EPDM. 4. Sizing: Line size. 5. Fittings and Components: All Fittings and Components shall meet ANSI standards and be totally compatible with readily available components in North America (except as allowed for 8" valves and above – Proper Companion Flanges must be supplied). 6. Close-Off (Differential) Pressure Rating: Combination of actuator, DPRV action, and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head. 7. Valves shall be manufactured by one manufacturer throughout the project. 8. PICV's shall be supplied by the PICV manufacturer only; "branded or 3rd party" PICV's (those products which have been purchased from a manufacturer and labelled as manufactured by a supplier) are not acceptable. 	
	<p>B. Electronic Actuators: Direct-mounted self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force and shall be from the same manufacturer as the pressure independent control valve; branded or 3rd party actuators must be submitted and approved prior to bid. The actuator shall provide visible position indication. Fail positions on power failure shall include in-place, open or closed as noted in the ATC / BAS controls specifications.</p> <ol style="list-style-type: none"> 1. Valves: Sized for maximum circuit flow rate, generally line sized. 2. Actuator to Coil Characteristics: Actuators shall be matched to provide the Heat Exchanger or Coil Characteristics of the product to be controlled – either Linear or Equal Percentage. <ol style="list-style-type: none"> a. Actuators for Equal Percentage Characteristic coils shall be field set to Equal Percentage characteristics or possess built in adjustment features to provide an Alpha (α) Characteristic matching the α Characteristic of the coil or Heat Exchanger. 3. Overload Protection: Electronic overload or digital rotation-sensing circuitry. 4. Fail-Safe Operation: Mechanical, spring-return mechanism or Capacitance return. Power Requirements (Two-Position Spring Return): 24-V ac. 5. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc. 6. Proportional Signal: 0 to 10Vdc or 2 to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal. 7. Actuators for service above Ceilings shall possess UL listings and Approvals. 8. Temperature Rating: 40 to 104 degrees F. 	
	<p>C. 3rd Party Test Results: The manufacturer shall submit in his submittal documentation package a set of 3rd Party test reports from a recognized testing agency verifying the accuracy and operation of the submitted valves and associated actuators. Separate reports for valves and actuators will not be acceptable.</p>	
	<p>D. Acceptable Manufacturers:</p> <ol style="list-style-type: none"> 1. Base Bid: Danfoss AB-QM PICV valves 2. Alternate Deduct Manufacturer Bids may be Accepted with Approval by the Engineer Prior to Bid, including submission of 3rd Party Test Reports. 	

2.8 AUTOMATIC AIR VENTS

- A. Automatic air vents shall be constructed of brass or stainless steel and be installed where required. Automatic air vents shall be suitable for the system and for the system working pressure and temperature. Vents shall be designed to eliminate air from the system automatically without permitting the passage of any water and shall be similar and approved equal to the following:
1. 150 psig working pressure service - Sarco Type 13WS, Taco or approved equal.
 2. 300 psig working pressure service - Sarco Type 13WHS, Valmatic or approved equal.

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3. Automatic air vents shall have an approximate 3/4" IPS inlet connection and 3/8" outlet. Provide 3/4" steel pipe suitable for the pressure service between main pipe and inlet. Provide 3/8" OD hard drawn Type L copper tubing from vent outlet for overflow in case of defective action. Copper tubing shall run to a suitable drain. Provide 3/4" stop valve, as specified in the Subsection titled "Controlling Valves" herein, in the inlet line for servicing of automatic air vent.

2.9 PIPE HANGERS AND SUPPORTS

- A. All piping throughout the building shall be thoroughly and substantially supported with listed hangers and supports. Furnish and install any special hangers or supports that may be required by the building construction. The design, selection, spacing and application of horizontal pipe hangers, supports, restraints, anchors and guides shall be in accordance with the latest editions of ANSI/MSS SP-58 "Pipe Hangers and Supports: Materials, Design, Manufacture, Selection, Application, and Installation."
- B. All horizontal black or galvanized steel water pipe shall be supported on Anvil Figure 260 or approved equal, adjustable wrought clevis hangers with the following exceptions. Piping subject to movement shall be mounted on Anvil Figure 177 or approved equal pipe roller supports, or on Anvil Figure 257 or approved equal pipe sliding supports. Roller guides are not acceptable to support horizontal water piping subject to both longitudinal and transverse movement. Certain piping, as shown on the Drawings, shall be supported from structural frames mounted on the floor. The structural frames shall be provided and installed by this Subcontractor and they shall be reviewed by the Project Structural Engineer.
- C. Horizontal copper pipe shall be supported on Anvil Figure CT-65, or approved equal, plastic coated clevis hangers. Steel hangers similar to Anvil Figure 65, CT-65, or approved equal, may be used if taped at each horizontal and vertical support point with Scotchrap No. 43 or approved equal pipe protection dielectric tape. Dielectric tape shall be spiral wrapped to at least 1/2" on either side of the support device.
- D. All vertical pipes not specified to be supported on vibration isolation shall be supported as follows:
 1. Vertical pipes 12" in diameter and smaller shall be supported at least at every other floor with a minimum of two (2) bolt riser clamps, designed for the load and manufactured by Anvil or approved equal riser clamps. Any welding, extensions or modifications of the riser clamps shall be reviewed by the Project Structural Engineer.
 2. Vertical pipes 14" in diameter and larger shall be supported at least at every other floor, with structural steel channels and gussets welded to the pipe. Structural steel supports shall be provided by this Division and they shall be reviewed by the Project Structural Engineer.
 3. Vertical copper pipes shall be supported on Anvil Figure 261C or approved equal, minimum two (2) bolt plastic coated riser clamps at least at every other floor.
- E. All vertical pipes requiring vibration isolation shall have spring isolators as specified in Section 23 05 48 titled "Vibration and Seismic Controls for HVAC Piping & Equipment". Riser clamps and steel channels supports shall be as specified herein and as indicated on the Drawings with provisions for attachment to the vibration isolators. Welded extensions to riser clamps to accommodate vibration isolators are unacceptable.

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	F.	Concrete inserts for hanger rods shall be Anvil Figure 282, Figure 152 or approved equal, for pipe sizes up to 8" IPS. For over 8" IPS pipe, an insert reinforced with steel anchor bars or suitable steel plate embedded in the concrete may be used. Hanger rods, inserts, etc., shall be sized and installed as recommended by the hanger manufacturer for the service intended.
	G.	Metal deck concrete insert shall be Carpenter & Patterson, Inc. Figure 143, galvanized fabricated steel metal deck ceiling bolt, Rawl Double FF-S-325 or approved equal.
	H.	Anchors in concrete shall be ICBO approved and shall be installed in strict accordance with approved ICBO "Research Reports" for the specific anchor used.
	I.	The Subcontractor shall submit pipe hanger and support details and other details as required by the Architect or Mechanical Engineer, to the Project Structural Engineer for review and approval prior to submission to the Engineer.
	J.	Hangers on piping exposed to weather or in the cooling tower enclosure shall be hot dipped galvanized or cadmium plated after fabrication.
	K.	Refer to Section 23 05 48 titled "Vibration and Seismic Controls for HVAC Piping & Equipment" for additional requirements. The location and type of supports, load imposed on the structure at the support, anchor points and forces shall be indicated on the "Coordination Drawings" and submitted to the Project Structural Engineer. Refer to Section 23 05 00 for additional requirements.
2.10		PIPE COVERING PROTECTION SADDLES AND SHIELDS
	A.	Furnish and install pipe covering protection shields or saddles as required by MSS SP-69 for all insulated piping at the locations of all supports. The insulation may be applied directly over a clevis type pipe hanger without the use of pipe shields for heating hot water systems only.
	B.	Protection shield length and gauge thickness for use with clevis type hangers and any type of cold water (33°F to 59°F) support shall be as specified for Type 40 protection shields in the current edition of MSS SP-69. Protection shields shall be galvanized and shall be arranged to cover one-half of the circumference of the insulation and shall be mounted on the outside of the insulation with insulation blocking between the pipe and shield to prevent crushing of insulation. Blocking on piping shall be furnished and installed as specified in Section 23 07 00 titled "HVAC Insulation". The Subcontractor shall provide factory certification of gauge thickness and length of shields subject to point loading or used with roller supports.
	C.	Pipe covering protection saddles equal to Anvil Figure 160 Series shall be provided at all supports, other than the steel band or sliding types, as required by the current edition of MSS SP-69 for hot water systems (120°F and above). Protection saddles shall be welded to the piping and shall be of sufficient length to maintain contact at supports at all conditions of the pipe movement. After welding, fill void between saddle and pipe with sectional insulation or approved insulating cement as specified in Section 23 07 00 titled "HVAC Insulation".
2.11		THERMOMETERS
	A.	Thermometers shall be filled with blue colored spirit (organic) fluid having scale length of not less than 9" and scale divisions of 2°F or less. Range shall be as specified or as required for the duty.

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B.	Solar powered digital thermometers shall have 3/8" LCD display, hi-impact ABS case, a 1% accuracy over a range of -40°F to 300°F and be readable at 10 Lux (1-foot candle). The sensor shall be glass passivated thermistor.	
C.	Thermometers shall be installed as shown on the Drawings. Thermometer wells shall be installed as shown on the Drawings and as required by Division 28. Coordinate thermometer well requirements with Division 28. All thermometer wells shall be constructed of brass or stainless steel and where installed in insulated piping shall have at least 2-1/2" lagging extension. Pressure temperature ratings of each well shall be suitable for the system in which it is installed in accordance with the paragraph titled "Design Conditions" in Section 23 05 00 and as indicated on the Drawings. All wells shall be filled with silicon and be complete with caps and chains.	
D.	Thermometers shall have stems with insertion lengths of roughly half the pipe diameter. Thermowell insertion length shall in on instance be less than 2½".	
E.	Thermometers shall have the temperature ranges listed herein and shall be installed at the following locations and where indicated on the Drawings or specified elsewhere.	
F.	Chilled water supply to and return from each outside air handling unit: 0-100°F.	
G.	Chilled water entering the Central Plant machine room and leaving each water chilling unit and each heat exchanger: 0-100°F.	
H.	Condenser water entering the Central Plant machine room and leaving each water chilling unit and each heat exchanger: 0-100°F	
I.	Thermometers and wells must be of at least the quality and design specified. Submit a list detailing design and construction of thermometers for review by the Engineer.	
J.	Provide pressure or temperature test plugs at the supply and return to all field and factory air handling units and water cooled packaged air conditioning units with multiple coils and at the inlet and outlet of each automatic control valve and as indicated on the Drawings. At the Subcontractor's option, factory built flow assemblies containing such items as stop valves, strainers, flow control devices, pressure-temperature test ports, etc., manufactured by Flow Design Inc., Nexus Valve or Texas Fairfax will be acceptable. Taps shall be Pete's Plug, 1/2" NPT, brass with Nordel core, Model 710 or Model 710XL for insulated pipe, Flow Design Inc. Super Seal, SISCO, Miljoco PT, or Watts. In addition, the Contractor shall supply the Owner with six (6) pressure gauge adapters with 1/8" O.D. probe and six (6) 5" stem pocket testing thermometers: four (4) 25-120°F and two (2) 0-220°F.	

2.12 GAUGES AND GAUGE STOP VALVES

- A. Gauges shall be bourdon tube with minimum 4-1/2" dial and die cast aluminum case with black enamel finish. The movement shall be all stainless steel with Grade A phosphor bronze bourdon tube brazed at socket and tip. The accuracy of the gauge shall be within 1/2 percent of the scale range. The pointer shall be the micrometer adjustment type recalibrated from the front. Pressure, compound and differential pressure gauges shall have suitable scale ranges, shall be submitted and are subject to the review of the Engineer. Graduations shall be one pound or less on all gauges where this is standard for the required range.

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B.	Gauges shall have 1/4" IPS connections and shall be Moeller "Vantage" or Miljoco 1100-25-B gauges with Case Style No. 2, ASME B 40.1 Grade 2A with needle valve or approved equal.	
C.	Gauges shall be installed on the suction and discharge piping for each pump, inlet and outlet of each heat exchanger and at locations as indicated on the Drawings. Gauges shall be furnished complete with stop valves as specified herein suitable for the pressure and temperature ratings of the system in which they are installed in accordance with the paragraph titled "Design Conditions" in Section 23 05 00.	
D.	In addition, differential pressure gauges shall be installed across each central plant strainer and as indicated on the Drawings. Gauges shall have at least a 2½" diameter dial with two (2%) percent full scale accuracy and a differential pressure range of 0-5 psig unless otherwise noted on the Drawings and shall be similar to Orange Research, Inc. Type 1201PG-1, Dwyer or approved equal.	
E.	Gauges shall be bourdon tube with minimum 4-1/2" dial and die cast aluminum case with black enamel finish. The movement shall be all stainless steel with Grade A phosphor bronze bourdon tube brazed at socket and tip. The accuracy of the gauge shall be within 1/2 percent of the scale range. The pointer shall be the micrometer adjustment type recalibrated from the front. Pressure, compound and differential pressure gauges shall have suitable scale ranges, shall be submitted and are subject to the review of the Engineer. Graduations shall be one pound or less on all gauges where this is standard for the required range.	
F.	Gauges shall have 1/4" IPS connections and shall be Moeller "Vantage" or Miljoco 1100-25-B gauges with Case Style No. 2, ASME B 40.1 Grade 2A with needle valve or approved equal.	
G.	Gauges shall be installed on the suction and discharge piping for each pump, inlet and outlet of each heat exchanger and at locations as indicated on the Drawings. Gauges shall be furnished complete with stop valves as specified herein suitable for the pressure and temperature ratings of the system in which they are installed in accordance with the paragraph titled "Design Conditions" in Section 23 05 00.	
H.	In addition, differential pressure gauges shall be installed across each central plant strainer and as indicated on the Drawings. Gauges shall have at least a 2½" diameter dial with two (2%) percent full scale accuracy and a differential pressure range of 0-5 psig unless otherwise noted on the Drawings and shall be similar to Orange Research, Inc. Type 1201PG-1, Dwyer or approved equal.	
2.13	DIESEL ENGINE EXHAUST PIPING	
A.	A stainless steel flexible connector with a minimum 18" long flexible corrugated section, flanges with gaskets on both ends between exhaust pipe and engine and a muffler will be provided by Division 26 to the Division 23 Subcontractor for installation.	
B.	Piping shall be ASTM A 53 continuous weld or ERW black steel. Electric resistance welded pipe shall be fully normalized in the weld area after fabrication welding.	
C.	Piping 5" and larger shall be ASTM A53 black steel Type "S" or Type "E" (electric resistance welded). Electric resistance welded pipe shall be fully normalized in the area of the weld after fabrication welding.	

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D.	Steel pipe thickness shall be minimum schedule 20.	
E.	Steel piping systems shall be butt-welded construction in strict accordance with ANSI B31.9, except in locations where flanges are required for connection to equipment.	
F.	Fitting material shall be as follows:	
	<ol style="list-style-type: none"> 1. Pipe fittings shall be welded fittings, ANSI B16.9 with wall thickness and material identical to installed pipe. Flanges, where required, shall be ANSI B16.5, forged steel welding neck type as required. 2. Weld fittings shall be factory made and shall be full line size. 3. At each joint the flanges shall have matching flat faces or raised faces and the flanges shall be identical in configuration. Steel flanges shall have a minimum tool finish. 4. Flange bolting materials shall be carbon steel ASTM A 307 Grade A hexagon head bolts and hexagonal nuts. Furnish Grade A bolts for flanged joints in piping systems where one or both flanges are cast iron. Flange bolt thread lubricant shall be an antiseize compound designed for temperatures up to 1000°F and shall be Crane Antiseize Thread Compound or approved equal. Where the configuration or arrangement of flanged fittings prevents the use of machine bolts, stud bolts shall be used. 	

2.14 REFRIGERANT PIPING

- A. Furnish and install all necessary refrigerant piping, fittings, valves, traps, etc., as required for a complete and operating refrigerant system. Piping shall be sized and installed as shown on the Drawings and/or as described herein and shall be supported in a manner so as to avoid the transmission of machinery noise and/or vibration to the building structure. Pipe supports shall be spaced not more than 10 feet apart.
- B. Refrigerant piping, sizes as well as arrangement, shall be approved by the air conditioning unit manufacturer based on the actual line lengths, number of fittings, and accessories installed. It shall be clearly understood that any changes which are required to comply with the manufacturer's recommendations shall be included as part of this Contract. Refrigerant piping shop drawings shall be approved in writing by the air conditioning unit manufacturer prior to submittal to the Engineer for review.
 1. The materials to be used for the refrigerant piping shall be Type "L" hard copper construction, using Mueller "Streamline" wrought copper solder fittings, as manufactured by Chase or Anaconda, with long radius bends.
 2. Pipe and fittings shall be cleaned according to the air conditioning unit manufacturer's recommendations.
 3. After the pipe is thoroughly cleaned, the sweat joints shall be made as follows:
 - a. Tubing shall be cut so ends are perfectly square, using a pipe cutter. Do not use a hacksaw.
 - b. The surface of the pipe and fittings to be soldered shall be burnished until all dirt and oxide are removed.
 - c. The joint should then be heated to the proper brazing temperature so that the Sil-Fos-5, or approved equal, solder will flow to all parts of the joint. "Oil Pump" dry nitrogen shall be used to fill the pipe and fittings during brazing to prevent the formation of copper oxide.

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	<ol style="list-style-type: none"> 4. The piping system shall be pressure-tested and leak checked twice in the presence of the Engineer. 5. After the system has been double checked for leaks, it shall be blown clean with dry nitrogen. 6. The system shall be evacuated with a vacuum pump. After evacuating is completed, break the vacuum with dry nitrogen. The same procedures shall be followed two (2) more times. 7. Replace the refrigerant drier. 8. The system shall be evacuated and dehydrated to a vacuum equivalent of a 28" column of mercury. Reduce the moisture content of the system to 100 microns or less, subject to the review of the Engineer before charging with refrigerant for operation. 	
	<p>C. Furnish and install all necessary refrigerant piping accessories that are indicated on the Drawings and/or specified hereinafter and as required by the air conditioning unit manufacturer.</p> <ol style="list-style-type: none"> 1. Manual Isolation Valves: Furnish and install manual isolation valves as indicated on the Drawings or required for maintenance and servicing the piping system and equipment. Valves shall be sized the same as the refrigerant lines in which they occur. All valves shall be back-seating angle type, packed with wing cap. Valves shall be designed for use with the refrigerant being provided and shall be as manufactured by Henry Valve Company, or Engineer approved equal. 2. Thermal Expansion Valves: Furnish and install a thermal expansion valve for each refrigeration circuit direct expansion coil. Valves shall be properly sized for the refrigeration load on the cooling coil and shall be designed to automatically maintain a constant superheat at the refrigeration outlet. Valves shall be provided with equalizing connection and superheat adjustment, a stop-on thermal bulb, and shall be as manufactured by the Sporlan Valve Company (no substitution). Provide a sight glass upstream of all thermal expansion valves. 3. Sight Glass/Moisture Indicator: Furnish and install a sight glass/moisture indicator immediately ahead of each thermal expansion valve and other locations shown on the Drawings. Sight glass/moisture indicator shall be installed as recommended by the manufacturer and shall be Henry Valve Company Type MI-20 "Dry-Vu" or approved equal. 4. Filter/Drier: Furnish and install a properly sized filter/drier on each refrigeration circuit. Filter/drier shall be installed as recommended by the air conditioning unit manufacturer. 5. Solenoid Valve: If required by the air conditioning equipment manufacturer, furnish and install a properly sized liquid line solenoid valve on each refrigeration circuit. Solenoid valve shall be installed and controlled as recommended by the air conditioning unit manufacturer. 6. Accumulator: If required by the air conditioning equipment manufacturer, furnish and install a properly sized suction line accumulator on each refrigeration circuit. Accumulator shall be installed as recommended by the air conditioning unit manufacturer. 	
2.15	MISCELLANEOUS PIPING ACCESSORIES	
	<p>A. Furnish and install all necessary miscellaneous piping accessories that are shown on the Drawings and/or specified herein:</p> <ol style="list-style-type: none"> 1. Check valves 2" and smaller shall be Jenkins Figure 996 for 150 psig working pressure systems for 300 psig systems. 	

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2. Check valves, larger than 2", located in chilled and condenser water pipes shall be spring loaded quiet type. Check valve non-shock pressure temperature rating shall be same as specified for piping in which it is installed. Check valve shall have full circle threaded lug body, grooved body or flanged body. At the contractor's option, spring loaded quiet type check valves with grooved ends similar to Victaulic Style 716 and Series W715 or Gruvlok 7811 will be acceptable. Wafer valve type installed between companion flanges will not be acceptable. Check valves on pump discharges shall be installed with the valve shaft perpendicular to the pump shaft.

B. Strainers shall be similar and approved equal to the following:

1. All water strainers shall be similar and approved equal to the following Mueller Steam Specialty Company Model numbers listed.
 - a. 150 psig system working pressure - up to 2". Muessco No. 11, 400# WOG, iron body with perforated 20 mesh monel or stainless-steel screen with clean out and screwed ends.
 - b. 150 psig system working pressure - 2-1/2" through 24". Muessco No. 758, 150# WOG, iron body with perforated monel or stainless-steel screen with 1/8" perforations for sizes through 4" and 5/32" perforations for 5" and above, with clean out and Class 125 ANSI B16.1 flanged ends.
 - c. 300 psig working pressure - up to 2". Muessco No. 11, 400# WOG, iron body with perforated 20 mesh monel or stainless-steel screen with clean out and screwed ends.
 - d. 300 psig working pressure - 2-1/2" to 24". Muessco No. 752, 300# WOG, iron body with perforated metal monel or stainless-steel screen with 1/8" perforations in sizes through 4" and 5/32" perforations for 5" and above, with clean out and Class 250 ANSI B16.5 flanges.
 - e. At the Contractor's option, grooved and wye type strainers similar to the following will be acceptable.
 - 1) 150 and 300 psig working pressure – 2" to 12", Victaulic Style 732 wye type or Gruvlok 758, 768, ductile iron body with perforated 304 stainless steel baskets with 0.062" perforations in sizes 2" through 3", and 0.125" perforations for 4" through 12", grooved ends.
 - 2) 150 and 300 psig working pressure* - 2" to 24", Victaulic Style 730 and W730 or Gruvlok 7260 tee type, ductile iron or carbon steel body with perforated 304 stainless steel basket with 0.063" perforations in sizes 2" through 3", 0.126" perforations for 4" through 16" and 0.203" perforations for 18" through 24", grooved ends.

C. Branch Pressure Reducing Valves:

1. Branch pressure reducing valves shall maintain a constant downstream pressure (plus or minus 3 psig) regardless of changing inlet pressures and/or flow rates. All flow conditions from zero to full flow are to be handled in a stable manner. The valve shall close drop tight when the downstream pressure rises to the setting of the spring. No pressure "creep" or leak can be tolerated. Valve body and cover shall be of an all bronze construction. The trim shall be 416 stainless steel. The valve shall contain an integral chrome nickel stainless steel strainer and low flow bypass. All repairs shall be possible without removing the valve body from the line. The valve body shall be constructed of

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NPT union tail pieces at the inlet and outlet of the valve. The valve shall be similar in all respects to "Cla-Val Co. 990" or 90-42 pressure reducing valve as manufactured by Cla-Val Co. or "JRG Gunzenhauser" PRV valve of same configuration is an approved alternate. No other substitutions will be accepted.

D. Bypass Filters:

1. Bypass filters shall be similar and approved equal to MSO and UMO Series medium pressure flow filters as manufactured by Filterite Corporation, or Nowata Filtration "A" Series and shall be constructed as follows:
 - a. Bypass filter shall be carbon steel vertical tank type housing with integral angle iron leg supports and base plates for floor mounting. Housing shall have 2" NPT side inlet and outlet connections with 1/2" NPT drain and 1/4" vent connections as shown on the Drawings.
 - b. Housing shall have easy opening and closing top with ethylene propylene or Buna N O-ring seal and four (4) or six (6) captive eye bolts for internal cartridge filter tube replacement. Bypass filter shall be rated for working pressures of the system in which they are installed as indicated on the Drawings.
 - c. Internal cartridge filters shall be CUNO Micro-Klean III filter cartridges with 10-micron porosity on a tin-plated core. Provide and install a new, clean set of filter tubes in all bypass filters at time of issuance of a Substantial Completion Certificate by the Owner.
 - d. Bypass filters shall be rated for at least 18 gpm flow with 3.0 psig initial pressure drop and shall have configuration as indicated on the Drawings.
 - e. Bypass filters shall be installed into a bypass piping system on the chilled and heating hot water system. Filters may also be used for feeding an aqueous solution of sodium nitrite based corrosion inhibitor into the water systems as outlined in Section 23 25 00 titled "HVAC Water Treatment".

2.16 WATER CHILLING UNIT REFRIGERANT RELIEF PIPING

- A. Relief piping from the water chilling unit rupture disc shall be same as for "Chilled, Heating Hot Water and Condenser Water Piping", except it may be Schedule 20. Relief piping shall be routed outside the building. Provide a braided flexible connector at the connection to the water chilling unit.

2.17 WATER TREATMENT PIPING

- A. Piping for the chilled water treatment system shall be as specified for "Chilled, Heating Hot Water and Condenser Water Piping".
- B. Piping for the condenser water treatment system shall be as specified in Section 23 25 00 titled "HVAC Water Treatment".

2.18 FUEL OIL PIPING

- A. The fuel oil piping system for the emergency generator and/or other systems as specified or indicated on the Drawings, shall be furnished and installed by this Contractor as specified in Section titled "Facility Fuel Systems" and under the direction of the generator system and/or other systems' manufacturer as specified in Division 26. The emergency generator system is

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furnished under Division 26. See Division 26 Specification Section 26 32 00 titled "Packaged Generator Assemblies" and other systems for requirements.

PART 3 - EXECUTION

3.1 GENERAL

- A. All pipe materials shall be as specified herein and shall be installed in accordance with the latest industry standards, per the manufacturer's recommendations, and as indicated on the Drawings. All piping shall be made up and installed in a manner that permits expansion and contraction caused by changes in temperature and pressure. This shall be accomplished by the use of expansion loops as required and as shown on the Drawings and by installation of supports that will permit the movement of the pipe without undue stress and by any other precautions that might be deemed necessary by the Engineer. Refer to Section 23 05 48 titled "Vibration and Seismic Controls for HVAC Piping & Equipment".
- B. Piping exposed in all rooms shall be installed as nearly as possible parallel with or at right angles to the building walls. Install all pipe straight and true. Springing or forcing piping into place will not be permitted unless specifically called for. Install piping in such a manner as to prevent strain on equipment connections. Install piping in such a manner as to eliminate all static and dynamic conditions of loading on equipment connections.
- C. Piping in finished portions of the building, except in mechanical equipment rooms or where otherwise indicated on the Drawings, shall be concealed.
- D. All piping shall be carefully graded so as to eliminate traps and pockets. Provide means for drainage by valved connections with pipe plugs for water traps and with automatic air vents for air pockets. Automatic air vents shall be valved.
- E. Where horizontal pipes change size, eccentric fittings shall be used, to prevent the pocketing of air, except where branch pipes connect into mains at water chilling unit connections.
- F. All welded elbows shall be long radius type.
- G. Make all joints smooth and unobstructed inside. Ream all pipe ends to remove burrs. Remove all obstructions and debris inside the piping systems prior to installation.
- H. Install unions or flanges at all equipment connections, control valves, and elsewhere as indicated on the Drawings. Flanges at water chilling units shall be positioned so that no more than a four (4) foot length of pipe and one (1) elbow shall be required to be removed for maintenance and cleaning of the condenser and evaporator vessels.
- I. Make welded joints on the piping system with continuous welds, without backing rings and with pipe ends beveled before welding. Gas cuts shall be true and free from burned metal. Before welding, welding surfaces shall be thoroughly cleaned. The piping shall be carefully aligned and no weld metal shall Project inside the pipe.
- J. Connections between dissimilar metal piping shall be made with dielectric insulating fittings or waterways.

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K.	All piping shall be of the sizes indicated and shall be routed as indicated on the Drawings, or as required, to serve all equipment and systems.	
L.	All piping materials, fabrication, erection, flanging, welding, tests, etc., shall be in accordance with American National Standard Code for Pressure Piping, current edition. Wire type "Short Arc" welding machines will not be acceptable for field welds, except where "shop procedures and methods" can be maintained for prefabrication of piping systems, such as the central plant piping, subject to the approval of the Engineer. Wire type "Short Arc" welding machines will be acceptable for shop fabricated piping. If in the opinion of the Engineer any "Short Arc" weld is found unsatisfactory, the use of the wire type short welding machine shall be discontinued for all remaining welding and re-welding the defective welds. The Engineer shall have unrestricted access, at all times during normal working hours, to the pipe fabrication facilities. The Subcontractor shall indicate in the piping submittals that all piping materials furnished for this Project are suitable for the service intended and comply with the requirements herein.	
M.	All welders shall be certified by ANSI B31.9 "Standard Qualification Welding Procedures, Welders and Welding Operators" or "Qualification Tests" in Section IX, ASME Boiler and Pressure Vessel Code. Furnish welder performance qualification test certificates for positions 2G, 5G or 6G made in strict compliance with the above codes. Welders shall be certified for the type of pipe material specified herein. All costs incident to procedures and welder's qualification tests shall be assumed by the Subcontractor. Two copies of the qualification test report and certification with welder's identification number, letter, etc., shall be submitted to the Engineer, via the Architect, for his file before any welding commences. Each weld shall bear the welder's identification mark permanently indented in the weld. Welding procedures shall also be in accordance with the requirements of the American Welding Society, current edition, where applicable.	
N.	The Contractor utilizing a grooved piping system shall provide a letter to the Engineer and Architect stating that a Project Site training session of at least two (2) hours was conducted for this Project by the grooved fitting manufacturer for the Subcontractor's supervisory and installing personnel. All grooved fittings, couplings, valves and specialties shall be of the same manufacturer. Grooving tools shall be of the same manufacturer as the grooved components. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.	
3.2	PIPE CLEANING	
A.	The Subcontractor shall furnish all required pipe cleaning chemicals, chemical feed equipment, materials and labor necessary to clean the chilled, condenser and heating hot water piping as herein specified. In addition, the Subcontractor shall permanently install necessary chemical injection fittings complete with stop valves and coupon racks, etc.	
B.	Hydrostatic Testing: After each hydrostatic leak testing procedure is complete, drain the system until empty. The chilled, condenser and heating hot water piping systems shall be internally chemically treated and protected during and after the hydrostatic testing procedure. Liquid for each hydrostatic test of piping shall be water and Nalco 2572 or approved equal mixed to a ratio of fifty (50) gallons of Nalco 2572 to 10,000 gallons of water or a higher concentration if recommended by the chemical manufacturer. The process shall be monitored by the chemical treatment manufacturer and a written report issued to the Engineer and Owner two weeks after completion of the Subcontractor's hydrostatic testing. At least sixty (60) days prior to the start of hydrostatic leak testing a two (2) foot long length of the typical piping installed on the	

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Project shall be sent by the Subcontractor to Nalco or another chemical manufacturer acceptable to the Owner to determine the composition of the internal pipe coating. Provide injection pumps, water meters and coupon racks to control and monitor the concentration. After leak testing and a sufficient time period to allow the interior of the piping to be chemically coated to prevent rust formation, the piping shall be drained until empty. Refer to Section 23 05 93 titled "Testing, Balancing and Adjusting".

- C. Refrigerant Piping System: After completion of the refrigerant piping systems and before charging, test the system with dry carbon dioxide at 250 psig for 24 hours. Test joints under pressure with soap solution. During the test, isolate expansion valves and other auxiliary devices to prevent damage due to high pressure.
1. After the initial pressure test has been completed and the system proved tight, introduce a mixture of refrigerant and dry carbon dioxide into the system at 150 psig and test all devices and fittings for leaks using a halide torch.
 2. Following the satisfactory completion of all tests, evacuate the system by means of a vacuum pump connected to the liquid line. After 20" of vacuum is obtained, close the suction and discharge valves at the compressor and continue evacuation for 24 hours. Vacuum shall be measured with a mercury column vacuum gauge.
- D. Pipe Cleaning and Flushing: The chilled water, heating hot water and condenser water piping shall be thoroughly cleaned and flushed as follows:
1. Cleaning shall not take place more than 14 days prior to system startup. The chemical manufacturer's representative shall be given 30 days notice prior to startup.
 2. Prior to the start of the chemical cleaning procedure the Subcontractor shall submit three - two (2) foot lengths of all foreign manufactured piping installed on this Project to the chemical manufacturer for analysis of the interior coating on the piping. Refer to Section 23 05 93 titled "Testing, Balancing and Adjusting" for additional requirements.
 3. Before the chemical cleaning procedure is begun, the Subcontractor shall install bypasses around water chilling units, air handling units, plate and frame heat exchangers, fan coil units, etc. in the chilled and condenser water systems and install a temporary skid mounted portable side stream filtering system. A single filtering system can be utilized and relocated to the system being cleaned. The filtering assembly shall have 6" flanged connections and multiple cartridge filters capable of at least 400 gpm, an integral Barco type flow venturi, and shall be pressure rated for the system to which it is connected. The filter cartridges shall be installed and changed out by the Subcontractor until the system is clean. The initial cartridges shall be twenty (20) microns, the intermediate set five (5) microns and the final set one (1) micron. The filtering assembly shall be removed by the Subcontractor when the piping systems are clean and accepted in writing by the Engineer and Owner.
 4. Refer to Section 23 25 00 titled "HVAC Water Treatment" for all pipe cleaning chemicals and compounds.
 5. The cleaning compound shall then be circulated in the system at a high flow rate for at least three (3) hours or the time period specified by the chemical manufacturer.
 6. The system shall then be drained until empty from its lowest point.
 7. Fill the system again with fresh water and flush thoroughly until clean water is obtained (maintain continuous blow down and makeup as required during flushing operation). A

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five (5) micron cartridge type strainer element at end of drain hose shall be utilized to confirm that discharge water is free of foreign material.

8. The cleaning and flushing procedure shall be approved in writing by the chemical manufacturer. The chemical treatment manufacturer shall be Nalco or another chemical company acceptable, in writing, to the Owner. The chemical manufacturer's representative shall supervise and certify in writing the cleaning and flushing of the piping systems. The Subcontractor shall provide and install injection pumps, water meters and coupon racks to control and monitor the cleaning process. See Section 23 05 93 titled "Testing, Balancing and Adjusting".
9. The Subcontractor shall provide pipe cleaning certification.

3.3 FACTORY TESTING

- A. All pipe, valves, fittings and accessories shall be tested in accordance with the latest applicable industry standards.

3.4 FIELD TESTING

- A. Refer to Section 23 05 93 for additional testing requirements for pipe, valves, fittings and accessories.

END OF SECTION 23 21 13