

SECTION 221116 – PLUMBING AND FIRE PROTECTION PIPING SYSTEMS

- 1.0 This section is intended to define the general installation requirements for the numerous plumbing and fire protection piping systems installed at the University of Pennsylvania. Codes which govern the actual sizing and installation of piping should be used during the design process. Welding shall conform to current standards and recommendations of the National Certified Pipe Welding Bureau and all OSHA, State and City fire protection, NFPA Standard 241, American Welding Society, ASTM, and the University's Office of Fire and Safety requirements.
- 2.0 Pipe and fittings shall be specified to meet one of the numerous industry standards such as ANSI, ASTM, AWWA, etc. and shall be suitable for the operating temperatures and pressures to be encountered on the project. Pipe stress analysis shall be provided when deemed necessary by the University Representative or the Project Engineer.
- 3.0 Piping and conduits shall be designed to run parallel with the lines of the building. Electrical conduits shall not be hung on hangers with any other service pipes. The different service pipes, valves, and fittings shall be installed so that after the covering is applied, there will not be less than 4 inches clear space between the finished covering and other work and between the finished covering or parallel adjacent pipes. Hangers on different service lines, running parallel with each other and nearly together shall be in line with each other and parallel to the lines of the building.
- 4.0 The minimum pipe shall be $\frac{3}{4}$ inch for plumbing systems, and 1 inch for fire protection systems. Size reductions may only occur immediately adjacent to equipment connections. Valves and specialties serving equipment shall be full pipe size, not the reduced equipment connection size.
- 5.0 Hangers shall be spaced to prevent sag and permit proper drainage of piping. A hanger shall be placed within 1 ft. of each horizontal elbow or valve.
- 6.0 Vertical runs of pipe and conduit less than 10 ft. long shall be supported by hangers placed one (1) foot or less from the elbows on the connecting horizontal runs. Vertical runs of pipe and conduit over 10 ft. long, but not over 30 ft. long, and not over 6 inches in size, shall be supported by heavy metal clamps. Clamps shall be bolted tightly around the pipes and conduits and shall rest securely on the building structure without blocking. When run in a shaft, support riser clamps on both sides of clamp. For pipes over 30 feet long or over 6 inches in size, support base of all vertical pipe stacks (except soil pipe stacks, generator exhaust stacks and copper water pipe risers) with a base leg. Cut top of base leg to shape and completely weld to heel of base elbow. Weld leg support to a bearing plate and bolt to floor. Locate base leg on vertical pipe centerline. All vent stack piping shall be supported from below roof. Provide springs for vibration isolation where piping system movement, expansion, or noise criteria dictate. Clamps may be welded to the pipes and placed below couplings.
- 7.0 In lieu of individual hangers, multiple (trapeze) hangers should be considered for water pipes having the same elevation and slope and for electrical conduits. Each multiple hanger shall be designed to support a load equal to the sum of the weights of the pipes, conduits, wire, and water, the weight of the hanger itself, plus 200 lbs. The size of the hanger rods shall be such that the stress at the root of the thread will not be over 10,000 PSI at the design load. No rod shall be smaller than $\frac{3}{8}$ inches. The size of the horizontal members shall be such that the maximum stress will not be over 15,000 PSI design load. A structural engineer shall review all loads imposed upon the structure.
- 8.0 Steam, condensate, and other hot service piping shall be designed with loops, bends, and offsets to allow for thermal expansion and keep stresses within the allowable limits of the piping material. Expansion joints or ball joints should be avoided if possible.

- 9.0 Roller-type pipe supports shall be specified where significant horizontal pipe movement will occur due to thermal expansion, and spring-type supports shall be specified where significant vertical movement will occur and where vibration isolation is needed due to building usage and program requirements.
- 10.0 Piping shall be designed and installed without undue stress or strain and run parallel to the lines of the building, except to grade them as specified in a neat and workmanlike manner using a minimum of fittings. Fittings, valves, and accessories shall be designed as may be required to meet the conditions of installation and accommodate service. Piping shall be designed to suit the necessities of clearance with ducts, conduits, and other work and so as not to interfere with any passages or doorways and allow sufficient headroom at all places. Install piping to preserve access to valves and accessories.
- 11.0 Gas-piping systems and other hazardous services shall be designed in strict compliance with applicable codes and NFPA.
- 12.0 Plumbing system vents, relief valves, rupture disc, etc., shall be piped safely outdoors. Overflow pipes, system drains, and relief devices shall be piped to suitable drainage facility locations and indirectly connected. Certain pieces of equipment may have high discharge rates that can quickly result in flooding; drains, sumps, or other receiving devices must be sized sufficiently and have the storage volume required. The discharge piping from all steam safety valves shall be piped to a drip pan elbow and then to a safe discharge point on the exterior of the building at a minimum height of 10 feet above roof level. The drain connections from each drip pan elbow shall be piped to a floor drain.
- 13.0 Unions and flanges on each side of all pieces of equipment and other similar items shall be designed in such a manner that they can be readily disconnected. Unions and flanges shall not be placed in a location which will be inaccessible after completion of the project.
- 14.0 The project engineer shall specify testing, and flushing, disinfection, balancing and purging procedures for each piping service installed on the project. Test procedures shall include all items required by code and be sufficient to prove all systems tight at conditions which exceed the maximum design conditions. Water sampling to establish a treatment plan, pipeline sterilization, positive pressure, and vacuum testing must be included as part of the procedures.
- 15.0 All piping systems shall be designed to meet seismic codes.
- 16.0 Underground piping shall comply with the following:
- A. All underground utility work within the right-of-way must follow the GPIS permitting system process. The A/E is responsible for entering the appropriate information in the system in a timely fashion to concur with the project schedule requirements.
 - B. All restoration by permit tee to be accordance with the Streets Department Standard Construction Item publication.
 - C. Laboratory waste within buildings shall be a separate system through the building wall. The laboratory waste systems shall be piped to a common sampling manhole before connected to the site sanitary system.
 - D. A/E shall coordinate the termination of services with the Utility Companies and project the costs of extending services to any new buildings or projects.

- E. Critical Utilities: On a project by project basis, the A/E and the University shall determine which utilities are critical to support the project during a utility failure. Consideration shall be given to multiple sources or utility connections to critical functions.
 - F. Provide isolation valves outside buildings (not in the street) as near to the connection to utility main and inside buildings before any branch connections or devices.
- 17.0 Cast iron hub-less pipe shall be manufactured and installed as per Cast Iron Soil Pipe Institute (CISPI) standards (latest edition) with provisions for supporting and bracing horizontal piping 5in. and larger as per the standard.
- 18.0 Pipe and fittings for all buildings shall be as defined as follows

Service		Abbreviation	Color Code	Pipe	Fitting	Joints
1.	Sanitary Drainage (>10 ft. outside of building)	SAN. S. W. V.	Green			
a.	Underground			A	I	u y
b.	Above ground within building			B	II	b
c.	Above ground within building (optional)			C	III	c
d.	Vent piping			C	I	u
e.	Vent piping (optional)			B	II	b
				C	III	c
2.	Laboratory/Photo Processing Drainage and Vent	LW.LV LW.LV	Green			
a.	Underground			D	IV	d white oakum
b.	Above ground (optional)			E	V	e
c.	Above ground			F	VI	f
3.	Biohazardous Waste and Vent	BW.BV	Green			
a.	Underground			D	IV	d
b.	Above ground			F	VI	f
4.	Storm water and misc. clearwater waste	SW.D	Green			
a.	Underground (>10 ft. outside of bldg.)			A	I	a
b.	Above ground			B	II	b
c.	Above ground (optional)			C	III	c
d.	Above ground (optional)			H	VIII	h
5.	Foundation drain	FD	N/A	W		a
6.	Condensate drain from equipment	CD	Yellow	C	III	c
7.	All Drainage and Vent Piping above Food Service Areas	N/A	Green	C	III	c
8.	Domestic Cold Water	CW	Green			
a.	Above ground – 2-1/2” and larger			J ₁	XI XXIV	k y
b.	Above ground 2-1/2” and larger (optional)			H	X	j
c.	Above ground 2” and smaller			J ₁	XI	k

d.	Underground 3" and larger			K	XII	l
e.	Underground 2-1/2" and smaller			L	XI	k
9.	Domestic Hot Water	HW	Yellow			
a.	Above ground – 2-1/2" and larger			J ₁	XXIV	k y
b.	Above ground 2-1/2" and larger (optional)			H	X	j
c.	Above ground 2" and smaller			J ₁	XI	k
d.	Underground 3" and larger			K	XII	l
e.	Underground 2-1/2" and smaller			L	XI	k
10.	Domestic Hot Water Recirculating	HWR	Yellow			
a.	Above ground – 2-1/2" and larger			J ₁	XXIV	k
	Service	Abbreviation	Color Code	Pipe	Fitting	Joints
						y
b.	Above Ground 2-1/2" and larger (optional)			H	X	j
c.	Above Ground 2-1/2" and smaller			J ₁	XI	k
d.	Underground 3" and larger			K	XII	l
e.	Underground 2-1/2" and smaller			L	XI	k
11.	Tempered Water	TW	Yellow			
a.	Above ground – 2-1/2" and larger			J ₁	XXIV	k y
b.	Above ground – 2-1/2 and larger (optional)			H	X	j
c.	Above ground – 2" and smaller			J ₁	XI	k
d.	Underground 3" and larger			K	XII	l
e.	Underground 2-1/2" and smaller			L	XI	k
12.	Drinking Water	DW	Green	J ₁	XI	k
13.	Laboratory Cold Water	LCW	Green			
a.	Above ground – 2-1/2" and larger			J ₁	VII XI	h
b.	Above ground – 2" and smaller			J ₁	XI	k
14.	Laboratory Hot Water	LHW	Yellow			
a.	Above ground – 2-1/2" and larger			J ₁	XI	h
b.	Above ground – 2" and smaller			J ₁	XI	k
15.	Laboratory Hot Water Recirculating	LHWR	Yellow			
a.	Above ground – 2-1/2" and larger			J ₁	XI	h
b.	Above ground – 2" and smaller			J ₁	XI	k
16.	Animal Drinking Water	ADW	Green	J ₁	XI	k
17.	Makeup Water	MW	Green	J	XI	c
18.	Softened Water	SW	Green	J	XI	k
19.	Distilled Water	DIS	Green	O	XVIII	n
20.	Deionized Water	DI	Green	P	XIX	o
21.	Reverse Osmosis Water Supply and Return	ROS/ROR	Green	Q	XX	p
22.	Oxygen	O	Yellow	R	XI	r
23.	Nitrogen	N	Green	R	XI	r

24.	Nitrous Oxide	NO	Yellow	R	XI	r
25.	Carbon Dioxide	CO	Yellow	R	XI	r
26.	Helium	H	Yellow	R	XI	r
27.	Medical Air	MA	Yellow	R	XI	r
28.	Medical Vacuum	MV	Yellow	R	XI	r
29.	Laboratory Air	LA	Yellow	R	XI	r
30.	Laboratory Vacuum	LV	Yellow	R	XI	r
31.	Gas Evacuation	GE	Yellow	R.	XI	r
32.	Natural Gas	G	Yellow			
a.	2-1/2" and larger			M	XIII	m
b.	2" and smaller			M	XV	j
c.	Underground			S	XXI	s
33.	Compressed Air	A	Blue			
a.	Optional			J	XI	c

	Service	Abbreviation	Color Code	Pipe	Fitting	Joints
34.	Fire Sprinkler/Standpipe-Aboveground	F(A)	Red			
a.	2" and smaller			V	X, XVI, XXII	j, v
b.	2-1/2" and larger			V	XXII	v
35.	Fire Protection Underground Piping	F(U)	Red	K	XII	I

19.0 Pipe material indicated in the above table shall be as follows

	Pipe Specification	Designation
1.	Cast iron hub and spigot pipe, service weight, ASTM A 74	A
2.	Cast iron hubless pipe, service weight, CISPI 301	B
3.	Copper drainage tubing, drain, waste, and vent, (DWV) ASTM B 306	C
4.	High-silicon iron alloy hub and spigot pipe, extra-heavyweight, ASTM A 518, Grade 1	D
5.	Underwriters Laboratories (UL) classified borosilicate glass, ASTM C 1053, FS DD-G-541B, MIL-P22561B (YD)	E
6.	Flame-retardant polypropylene acid resistant drainage pipe, ASTM D 635, Schedule 40	F
7.	Flame-retardant polypropylene acid resistant drainage pipe, ASTM D 635, Schedule 40	G
8.	Galvanized steel pipe ASTM A 53 Grade B, seamless, Schedule 40	H
9.	Porous concrete drain pipe, ASTM C 654 or AASHTO M-176	I
10.	Seamless copper water tube, ASTM B 88, Type K, hard	J
11.	Seamless copper water tube, ASTM B88, Type L, hard	J ₁

12.	Ductile iron water pipe, outside coated, AWWA C 104/A 21.4 cement mortar-lined, ANSI/AWWA C 151/A 21.51 pipe	K
13.	Seamless copper water tube, ASTM B 88, Type K, soft	L
14.	Black steel pipe, ASTM A 53/106 Grade B, seamless Schedule 40	M
15.	Black steel pipe, ASTM A 53/106 Grade B, seamless Schedule 80	N
16.	As required by program of requirements and required water quality	O
17.	Polypropylene pipe, Type 11 copolymer, ASTM D 4101	P
18.	As required by program of requirements and required water quality	Q
19.	Seamless copper water tube, ASTM B88, Type K, hard, prepared and labeled for oxygen service and sealed when delivered to the site	R
20.	Polyethylene pipe, ASTM D 2513, 690 kPa working pressure, standard dimension ration (SDR), the ratio of pipe diameter to wall thickness, 11.5 maximum	S
21.	Underground chilled water with restriction joints mecolay or triflex.	T
22.	Schedule 10 Seamless, welded or electric-resistance welded black steel or hot-dipped galvanized, ASTM A53-Grade A, ASTM A135 or ASTM A 795	U
23.	Schedule 40 Seamless, welded or electric-resistance welded black steel or hot-dipped galvanized, ASTM A53-Grade A, ASTM A135 or ASTM A795	V
24.	Extra strength perforated clay pipe, ASTM C 200	W

20.0 Fitting materials indicated in above table shall be as follows

Fitting Specification		Designation
1.	Cast-iron hub and spigot fittings, service weight, ASTM A 74	I
2.	Cast-iron hubless fittings, service weight, CISPI 301	II
3.	Wrought copper and bronze drainage fittings, ANSI Standards B16.23, ASNI/ASME B16.29	III
4.	High-silicon/iron alloy hub and spigot fittings extra-heavyweight, ASTM A 518, Grade 1	IV
5.	UL-classified borosilicate glass drainage fittings, ASTM C1053, FS DD-G-541B, or MIL-P-22561B (YD)	V
6.	Enfusion joint flame-retardant polypropylene acid-resistant drainage fittings, ASTM D635	VI
7.	Flame-retardant, polypropylene acid-resistant, mechanical joint-type drainage fittings, ASTM D635	VII
8.	Galvanized steel grooved-end fittings, and couplings, ASTM A 47M or ASTM A 536	VIII
9.	Porous concrete drainage fittings, ASTM C 654 or AASHTO M-176	IX
10.	Galvanized malleable cast-iron screwed fittings, ANSI Standard B 16.3	X
11.	Wrought-copper solder joint fittings, 68 kg, ANSI Standard B 16.18 or ASME/ANSI B 16.22 and ASTM B 687 copper pipe nipples with threaded end connections	XI

12.	Ductile iron pressure fittings, AWWA C 110/A 21.10, 1724 kPa	XII
13.	Steel butt-welding fittings, ANSI Standard B 16.9 using long-turn ells, ANSI Standard B 16.5 weld-neck or slip-on flanges and Bonney Forge Woodlets and threadlets, wall thickness to match pipe	XIII
14.	Black, malleable iron-grooved fittings and couplings, ASTM A47.	XIV
15.	Black, malleable iron-screwed fittings, 68 kg, ANSI Standard B 16.3	XV
16.	Black, cast-iron screwed fittings, ANSI Standard B16.4, 57 kPa less than 517 kPa and 113 kg for 517 kPa and more. Steam and condensate piping shall be 113 kg for all operating pressures	XVI
17.	Black steel socket wire fittings, ANSI Standard B 16.11 wall thickness to match pipe	XVII
18.	As required by program of requirements and required water quality	XVIII
19.	Polypropylene long-radius or DWV fittings, Type II copolymer, ASTM D4101	XIX
20.	As required by program of requirements and required water quality	XX
21.	Polyethylene socket fittings, ASTM D 2683 or butt-fusion fittings, ASTM F2206 molded	XXI
22.	Ductile Iron grooved-end fittings and mechanical type fittings, and couplings, ASTM A536	XXII

21.0 Joint materials indicated in above table shall be as follows

Joint Specification		Designation
1.	Premolded rubber compression gasket joint, ASTM C 564 or CISPI HSN	a
2.	No-hub neoprene gasket and stainless steel corrugated shield, CISPI 310 301 coupling	b
3.	Soldered using ASTM B 32, 95-5 tin-antimony or Grade Sn 96 tin-silver and flux containing not more than 0.2% lead	c
4.	Acid-resistant packing (white oakum) and molten lead-filled hub	d
5.	Glass-to glass connection with compression-type bead-to-bead and bead-to-plain end couplings	e
6.	Enfusion joint with maximum average burn time of 80 sec. and maximum extent of burning of 20 mm in accordance with ASTM D 635	f
7.	Mechanical joints and adapters, connections containing EVA components are prohibited	g
8.	ASTM A 183 coupling nuts and bolts, ASTM D 2000 rubber gaskets for water service	h
9.	Tongue and groove joints sealed with mortar	i
10.	Threaded using American Standard for pipe threads, ANSI Standard B 2.1	j
11.	Soldered using ASTM B 32, 95-5 tin-antimony or code-approved lead-free solder	k
12.	AWWA C111/A21.11 rubber gasket joint for mechanical-joint, ductile iron pressure pipe and fittings	l
13.	Welded engineering standards of the Mechanical Contractors Association of America, Inc. Part VII, Standard Procedure Specifications 1 & 2	m

14.	As required by program of requirements and required water quality	n
15.	Butt-fusion technique per ASTM D 2657, Section 9	o
16.	As required by program of requirements and required water quality	p
17.	Brazed: AWS A5.8 BcuP (brazing-copper-phosphorus) series, greater than 538°C melting temperature, cadmium-free brazing filler; the use of flux is prohibited	q
18.	Fusion of welded joints using electrically heated tools, thermostatically controlled and equipped with temperature indication.	r
19.	Brazed: AWS A5.8 brazing filler metal Type Bag-5 with AWS Type 3 flux, except Type BcuP or BcuP-6 may be used for brazing copper-to-copper joints	s
20.	Hub and spigot joints sealed with lead and oakum.	t
21.	EPDM gaskets as listed and approved with the mechanical grooved coupling	u
22.	Elastomer push-on joints with 'multi-tite' gasket.	v
23.	Polyvinyl chloride (PVC) with solvent cement.	w
24.	Coupling ASTM 536 with EPDM gasket ASTM D-2000	x

Methods and materials for wet taps, where permitted by the University Engineering Department, shall be submitted for approval by the A/E. Submittals shall include documentation on the products to be used with complete instructions and procedures to ensure successful wet taps.