
APPENDIX A

PIPE DISTRIBUTION SYSTEMS

The following pipe materials, jointing methods, and system components have been successfully used for various projects. Where trade names are mentioned, they are used only as an example to indicate general type, style, or construction. In no manner does this represent any endorsement or recommendation for use. There are materials suitable for applications other than those mentioned.

All materials used in a piping network must be carefully studied for pressure, compatibility, code acceptance, and suitability for use in any proposed project. The examples presented must not be used without all considerations outlined above, with the final choice of materials being the complete responsibility of the design professional.

Services:

High-Pressure Steam (Saturated)
 Atomizing Steam
 Boiler Feedwater
 High-Pressure Condensate
 Blowoff and Continuous Blowdown
 Chemical Feed Direct to Boiler

Pressure/Temperature Limits: 250 psig at 400°F

General Materials: Carbon Steel, Cast Iron

Item	Pipe size	Description	Reference standards
Pipe	2 in and smaller	Sch. 40, electric-resistance welded (ERW), or seamless steel (except for all condensate piping which shall be Sch. 80, ERW, or seamless steel)	ASTM A 53, Grade B
	2½–12 in	Sch. 40, ERW, or seamless steel (except for all condensate piping which shall be Sch. 80, ERW, or seamless steel)	ASTM A 53, Grade B
	14–18 in	Sch. 30, ERW, or seamless steel	ASTM A 53, Grade B
Joints	2 in and smaller	Socket-welded connections with 3000-lb forged steel socket weld fittings	ASTM A 105
	2½ in and larger	Butt welded connections	
Fittings	2 in and smaller	3000-lb forged steel socket weld	ASTM A 105 ANSI B 16.11
	2½ in and larger	Standard seamless butt weld carbon steel, end, long radius ells	ASTM A 234
Flanges	All	300-lb forged steel weld neck, raised face, bore to match pipe I.D.	ASTM A 181, Class 60 ANSI B 16.5
Flange bolting	All	Alloy steel bolt studs, thread full length, ANSI class 2A threads	ASTM A 193, Grade B7
		Heavy hex nuts	ASTM A 194, Class 2H ANSI B 18.2

Item	Pipe size	Description	Reference standards
Unions	2 in and smaller	300-lb malleable iron, threaded brass seat, ground joint	ASTM F 104
	OR	3000-lb socket weld, steel to steel seat, ground joint	
Gate valves	2 in and smaller	300-lb, bronze, union bonnet, rising stem, OS&Y, threaded connections	
	2½ in and larger	250-lb, cast iron, bronze trim, solid wedge, OS&Y, flanged ends	
Globe and angle valves	2 in and smaller	300-lb, bronze renewable disc, union bonnet, threaded connections	
	2½ in and larger	250-lb, cast iron, renewable seat and disc, OS&Y, flanged ends	
Check valves	2 in and smaller	300-lb, bronze, swing check, Y pattern, renewable discs and side plugs, screwed ends	
	2½ in and larger	250-lb, cast iron, swing check, trimmed, bronze renewable seat, discs and side plugs, flanged ends	
Gaskets	All	Nonasbestos with synthetic fibers and SBR binder	

Services:

Medium-Pressure Steam (Saturated)

Low-Pressure Steam (Saturated)

Medium-Pressure Condensate and Pumped Condensate

Low-Pressure and Humidification Condensate

Gravity Condensate

Safety Valve Vents

Deaerator Chemical Feed and Accessory Piping

Pressure/Temperature Limits: 125 psig at 350°F*General Materials:* Carbon Steel, Cast Iron, Bronze

Item	Pipe size	Description	Reference standards
Pipe	2 in and smaller	Sch. 40, ERW, or seamless steel (except for all condensate piping, which shall be Sch. 80, ERW, or seamless steel)	ASTM A 53, Grade B
	2½ in and larger	Sch. 40, ERW, or seamless steel (except for all condensate piping, which shall be Sch. 80 seamless steel)	ASTM A 53, Grade B
Joints	2 in and smaller	Threaded connections	ANSI B 2.1
	2½ in and larger	Welded connections	
Fittings	2 in and smaller	125-lb, cast iron, banded type, screwed	ASTM A 126
		OR	
	3000-lb forged steel socket weld	ASTM A 105 ANSI B 16.11	
	2½ in and larger	Standard seamless steel, butt weld, beveled ends, long radius ells	ASTM A 234
Flanges	All	150-lb forged steel weld neck, flat face when matching cast iron flanges, bore to match pipe I.D.	ASTM A 181, Class 60 ANSI B 16.5
Flange bolting	All	Alloy steel bolt studs, thread full length with heavy hex nuts	ASTM A 193, Grade B7

Item	Pipe size	Description	Reference standards
Unions	2 in and smaller	150-lb, malleable iron, brass trim, ground joint, threaded ends	ASTM A 197 ANSI B 16.3
		OR 3000-lb socket weld, steel to steel seat, ground joint	ASTM A 105 ANSI B 16.11
Gate valves	2 in and smaller	125-lb, bronze, union bonnet, solid wedge disc, rising stem, threaded connections	ASTM B 62
	2½ in and larger	125-lb, cast iron, OS&Y, bronze mounted, solid wedge, rising stem, flanged ends	ASTM A 126, Class B
Globe and angle valves	2 in and smaller	150-lb, bronze, union bonnet, renewable disc, threaded connections	ASTM B 62
	2½ in and larger	125-lb, cast iron, OS&Y, bolted bonnet, bronze mounted, renewable disc, flanged ends	ASTM A 126, Class B
Check valves	2 in and smaller	125-lb, bronze, horizontal swing check, renewable plugs and discs, threaded connections	ASTM B 62
	2½ in and larger	125-lb, cast iron, swing check, bolted cap, renewable plug and discs, flanged ends	ASTM A 126, Class B
Vertical silent lift checks	1 in and larger	125-lb, brass, flanged wafer type	
Gaskets	All	Nonasbestos with synthetic fibers and SBR binder, full face gaskets on flat face flanges	ASTM F 104

Services:

Nonpotable Fresh Water above Ground

Pond Water above Ground

River Water above Ground

Pressure/Temperature Limits: to 200 psig, 120°F (49°C)*General Materials:* Copper, Steel

Item	Pipe size	Description	Reference standards
Pipe	2–4 in	Copper type L, seamless hard drawn	ASTM B-88
Fittings	All	Wrought copper Cast copper	ANSI 16.22 ANSI 16.18
Joints	All	Solder (50-50 or 95-5 alloy)	ASTM B-32
Pipe	5–12 in	Carbon steel, Sch. 40	ASTM A 106 or ASTM A 53 Grade B
Valves	All	Same as potable water	
Fittings	All	Ductile iron grooved fittings Malleable iron grooved fittings	ASTM A 536 ASTM A 47
Joints	All	Cut grooved, 800 psi rated	Victaulic Style 77 EPDM gasket

Services:

Clean Steam and Condensate

Item	Pipe size	Description	Reference standards
Steam pipe	½–4 in	Stainless steel, Sch. 10S beveled ends	Type 316L, welded, ASTM A-312, TP316L
Fittings	½–4 in	Stainless steel, Sch. 10S butt weld	Type 316L, ASTM A 403, Grade WP 316L
Flanges	½–4 in	Forged stainless steel, 150# slip-on or weld neck	ASTM A-182, Grade F-316L/ASA B16.5
Gaskets bolting	All	Service type solid reinforced Teflon, ⅛-in thick Stainless steel, hex head machine bolts	Type 304, and monel nuts

Item	Pipe size	Description	Reference standards
Condensate pipe	1/2-4 in	Stainless steel, Sch. 40S threaded ends	Type 316L, ASTM A-403, seamless or welded
Fittings	1/2-4 in	Stainless steel, 150# threaded	Type 316L, ASTM A 182
		Stainless steel, 3000 psi at 100°F forged	ASTM A 182-F316
Unions flanges	1/2-4 in	Forged stainless steel, 150# slip-on or weld neck	ASTM A-182, Grade F-316L/ASA B16.5
Gaskets	1/2-4 in	Service type, solid reinforced Teflon, 1/8-in thick	
Bolting		Stainless steel, hex head machine bolts with heavy hex nuts	Type 304, and monel nuts
Steam and condensate		Pressure: 6000 at 200 psi gauge valve with bleed	
Instrument valves			
Ball valves	1/2-1 1/2 in	Stainless steel body, Type 316L, ball and stem with reinforced Teflon seals and seats butt weld ends	
Butterfly valves	2 1/2-4 in	Stainless steel, 150# lug	ASTM A351-CF8M
Gate valves	1/2-2 in	Stainless steel, 150 psi, bolted flanged yoke, bonnet outside screw, rising stem, threaded, 200 psi at 500°F	Type 316, ANSI B2.1, B16.34-1977; ASTM A351/296, Grade CF8M
	2-4 in	Stainless steel, 150# flanged, bolted flanged yoke bonnet outside screw, rising stem	Type 316; ANSI B16.10 and B16.34; ASTM A351, Grade CF8M

Item	Pipe size	Description	Reference standards
Check valves	1/2–2 in	Stainless steel, 150# raised face flanges	Swing check, Type 316L, integral seat, bolted cover with Teflon gasket, ANSI B16.5
Steam traps	1/2 or 3/8 in	Thermodynamic steam trap, renewable disc, stainless steel body and inner parts, threaded ends	ANSI/ASME PTC-39. 1 and ANSI B1.20.1
Gauge		Stainless steel, Sch. 10 butt welded, diaphragm, Type 316, and Teflon for all wetted parts, filled with high-temperature silicon	
Pigtail siphons		Stainless steel, 1/4-in MPT connections, 500 psi at 400°F	Type 316
Strainers	1/2–2 in (threaded)	Stainless steel, 600 psi at 842°F, Y type with standard 1/32-in screen	Type 316
	1/2–2 in (welded)	Stainless steel, 600 psi at 842°F	Type 316, ANSI B16.11

Services:

Instrument Air (All Sizes)

Pressure/Temperature Limits: 125 psig at 100°F*General Materials:* Copper, Brass

Item	Pipe size	Description	Reference standards
Tubing	1/4–3/4 in	Hard-drawn seamless copper tubing, type L	ASTM H 23.1 ASTM B-88
Joints	All	Soldered, 95/5 (tin/antimony) or Swagelok three-piece compression fittings	ASTM B 32
Fittings	All	Wrought copper solder or brass Swagelok three-piece compression tube fittings	ANSI B 16.22
Valves	3/8 in and smaller	Forged body (brass) regulating and shutoff, KEL-F tip stem with Swagelok end connections	
	1/2 and 3/4 in	150-lb, brass or carbon steel three-piece ball valve	
Unions	3/8 in and smaller	Swagelok union connections	
	1/2 and 3/4 in	Cast brass, ground joint, with solder ends	

Services:

Hot Water (Heating)
 Glycol-Water Solution
 HVAC Chilled Water
 Process Chilled Water
 Water Chemical Treatment Lines for Closed Systems (Sample and Chemical Injection Lines)
 Condenser Water
 Refrigerant Vent
 Water Chemical Treatment Lines for Open Systems (Sample and Chemical Injection Lines)

Pressure/Temperature Limits: 150 psig at 20 to 250°F for Steel Pipe
 150 psig at 100°F for Copper Pipe

General Materials: Carbon Steel, Copper

Item	Pipe size	Description	Reference standards
Pipe	2½ in and smaller	Sch. 40 seamless or welded carbon steel	ASTM A 53, Grade B ANSI B 36.10
		OR	
	4 in and smaller	Seamless copper tubing, type L	ASTM B 88
	3–12 in	Sch. 40, ERW, or seamless carbon steel	ASTM A 53
	14–18 in	Sch. 30, ERW, or seamless steel	ASTM A 53
	20–30 in	Sch. 20, ERW, or seamless steel	ASTM A 53
Joining materials	2½ in and smaller	Screwed joints with Teflon tape or paste	
	3 in and larger	Welded	ANSI B 16.4
		OR	
	Copper	95/5 (tin/antimony) solder	ASTM B 32
Fittings	2½ in and smaller	Malleable iron threaded fittings, class 150	ANSI B 16.3
		OR	
	Copper	Wrought copper solder joint pressure fittings	ANSI B 16.22

Item	Pipe size	Description	Reference standards
Fittings	3 in and larger	Steel butt welding fittings	ASTM A 234 ANSI B 16.9
		OR	
		For chiller and condenser water dedicated loop pipings in central plant (no main headers) and local building secondary chilled water distribution piping (downstream of local building pumps) only, use malleable or ductile iron grooved end fittings (not permitted in inaccessible chases)	ASTM A 47 ASTM A 536
Flanges	All	150-lb, forged steel, slip-on, flat or raised face to match equipment	ASTM A 105, Grade 2
Flange bolting	All	Alloy steel bolt studs; thread full length with heavy hex nuts	ASTM A 193, Grade B7
Dielectric fittings	All	Isolation flanges, unions and couplings	
Unions	2 in and smaller	Brass solder unions	
Ball valves (shutoff service only)	2½ in and smaller	150-lb, bronze, serviceable in-line, quarter-turn lever, soldered connections	ASTM B 62
		OR	
	2½ in and smaller	200-lb, cast steel body, chromed steel ball and stem, double TFE seal, threaded ends	
	3 in and larger	150-lb, ball valve, cast steel body, stainless steel ball and stem, double TFE seal, flanged ends	
Ball valves (balancing and shutoff service)	2½ in and smaller	250-lb, bronze body, ball type, threaded ends, with pressure taps, with memory stop slot	
	3 in and larger	150-lb, ball valve, cast steel body, stainless steel ball and stem, double TFE seal, flanged ends	

Item	Pipe size	Description	Reference standards
Butterfly valves (balancing and shutoff service)	3 in and larger	150-lb, high-performance butterfly valve, cast steel body, stainless steel disc and stem, TFE seal, threaded lug (for balancing, add memory stop slot)	
Swing check valves	2½ in and smaller	125-lb, bronze body, bronze disc and seat, soldered ends	
	3 in and larger	125-lb, cast iron body, bronze trim disc and seat, flanged ends	
Silent check valves	2½ in and smaller	150-lb, cast steel body, springloaded stainless steel disc, renewable stainless steel seat, flanged ends	
	3 in and larger	150-lb, cast steel body, spring-loaded stainless steel disc, renewable stainless steel seat, flanged ends	
Triple-duty valves	2½ in and larger	Straight pattern, cast iron body combining the functions of a silent check valve, a balancing valve, and a positive shutoff valve. Include a calibrated stem and pointer to indicate valve position. Valve stem shall be capable of being repacked under pressure. 175 psig working pressure at 300°F	
Safety relief valves	All	150-lb, bronze body, threaded connections, ASME rated	
Joints*	2½ in and smaller (On or below computer areas, use solder only.)	Threaded	
		OR	
	3 in and larger	Soldered	
		Butt welded	
		OR	
		Mechanical coupling grooved end (use only for chilled water and condenser water where permitted)	

*For piping installed on floor below finished raised-floors of computer and telecommunications spaces, use only soldered or butt-welded joints. Threaded joints are not acceptable.

Service:

Chilled Water "Underground"

Item	Pipe size	Description	Reference standards
Pipe	4–24 in	Mechanical joint, ductile iron cement lining	ANSI A21.51, ANSI A21.4
Fittings	3–12 in	250# mechanical joint, ductile cast iron, with cement lining	ANSI A21.10, ANSI A21.4
	14–24 in	150# mechanical joint, ductile cast iron, with cement lining	ANSI A21.10, ANSI A21.4
Valve box		2-piece screw or slip with water cap	
Valves	4–12 in	125# mechanical joint gate valve	ANSI A21.11
		125# flanged gate valve	ANSI A21.11
	14–24 in	125# mechanical joint gate valve	ANSI A21.11
Flanges	4–24 in	Ductile iron, 125# FF	ANSI A21.10
Boltings (for ANSI mechanical joints) (for ANSI flanged joints)		Carbon steel, tee head bolts with heavy hex nuts	
		Carbon steel, hex head machine bolts with heavy hex nuts	ASTM A307, Grade B
Gaskets (for ANSI mechanical joints) (for ANSI flanged joints)		Plain rubber	
		150# FF neoprene service gasket	

Note: 125# cast iron fittings may be substituted for ductile iron according to availability.

Services:

Above Ground Only

Fuel Oil Supply and Return to Boiler and Day Tank

Fuel Oil Tank Fill, Vent, and Overflow

Day Tank Vent, Overflow, Supply, and Return for Diesel Generator

Kerosene

Pressure/Temperature Limits: 150 psig at 300°F*General Materials:* Carbon Steel

Item	Pipe size	Description	Reference standards
Pipe	10 in and smaller	Sch. 40, ERW, or seamless steel	ASTM A53, Grade B
Joints	All	Welded, except where noted	ASTM A 53
Fittings	2 in and larger	3000-lb, forged steel, socket welded	ASTM A 234 82a ANSI B 16.9 78 B 16.11 80 B 16.28 78
	2½ in and larger	150-lb steel, butt welded	ASTM A 234 82a ANSI B 16.9 78 B 16.11 80 B 16.28 78
Flanges	2½ in and larger	150-lb forged steel, weld neck or socket weld, raised face	ASTMA 181 81 ANSI B 16.5 81
Unions	2 in and smaller	3000-lb forged steel with bronze-steel joints, socket welded	ASTM A 105 Grade
Stop valves	All	Butterfly valve, 150 psi rated carbon steel trim, Teflon seat and seal	
Check valves	2 in and smaller	150-lb class, forged steel, lift check, socket weld, SS trim	

Note: All piping shall be housed in a secondary containment of Schedule 40, transparent rigid PVC pipe and fittings, solvent-welded socket joints, fuel resistant and sloped to detection points.

Services:

Compressed Medical Gases, Interior, Above Ground

Gases for Pneumatic Tools

Vacuum Air (WAGD, Medical Vacuum)

General Laboratory Use

Pressure/Temperature Limits: Up to 200 psig*General Materials:* Copper

Item	Pipe size	Description	Reference standards
For pressures up to 200 psig			
Tubing	Up to 4 in	Hard-drawn copper tubing, seam-less type L	ASTM B 819
Fittings	All	Wrought copper solder end	ASTM B 16.22
Joints	All	Brazed, BCup filler metal, no flux, purged with nitrogen or argon	ASTM B 32
Valves	All	Three-piece ball valves, distribution piping only, 300 psi rated	
For pressures from 201 to 300 psig			
Tubing	Up to 4 in	Hard-drawn copper tubing, seam-less type K	ASTM B 819
Valves	All	Three-piece ball valves, distribution piping only, 400 psi rated All other components similar to above	

Service:

Safety Valve Drains

Pressure/Temperature Limits: 5 psig at 100°F*General Materials:* Carbon Steel, Copper

Item	Pipe size	Description	Reference standards
Pipe	¾–2 in	Sch. 40 welded carbon steel	ASTM A 53, Grade B
		OR	
Joints	¾–2 in	Hard-drawn seamless copper tubing, type L	ASTM B 88
		125-lb cast iron, banded, screwed connections	ASTM A 126, Class B
Fittings	¾–2 in	OR	
		Soldered	ASTM B 32
Unions	¾–2 in	125-lb cast iron, banded, screwed connections	ASTM A 126, Class B
		OR	
Valves	¾–2 in	Wrought copper solder joint fittings	ANSI B 16.22
		125-lb malleable iron, brass to iron seat, screwed connections	ASTM A 197
Valves	¾–2 in	OR	
		Wrought copper solder unions	
Valves	¾–2 in	125-lb bronze ball valve, screwed connections	

Services:

Domestic Cold, Hot, and Hot Water Return (Above Ground)
 Gravity Condensate Drains for AHUs, Ductwork, and Dehumidifiers
 Humidification Water
 Emergency Drench Equipment
 Trap Primers
 Safety Showers
 Slurry Return and Drain Water

Pressure/Temperature Limits: 90 psig at 40 to 140°F

General Materials: Copper, Steel

Item	Pipe size	Description	Reference standards
Pipe	4 in and smaller	Hard-drawn seamless copper tubing, type L	ASTM B 88
	6 in and larger	Sch. 40 seamless carbon steel, galvanized	ASTM A 53, Grade B
Joints	4 in and smaller	Soldered	ASTM B 32, lead free
	6 in and larger	Cut grooved split coupling	ASTM A 47 ASTM A 536
Fittings	4 in and smaller	Wrought copper solder joint fittings	ANSI B 16.22
	6 in and larger	Malleable or ductile iron, cut grooved	ASTM A 47 ASTM A 536
Flanges	6 in and larger	150-lb, malleable or ductile iron	ANSI B 16.5 ASTM A 47 ASTM A 536
Unions	1½ in and smaller	Red bronze	ASTM 75
Flange bolting	6 in and larger	Hex machine bolts with heavy hex nuts	ASTM A 307, Grade B
Unions	3 in and smaller	Wrought copper solder unions	ANSI B 16.22
AND			
		Dielectric, copper to steel	
Ball valves	2 in and smaller	150-lb, bronze, serviceable in-line, quarter-turn lever, soldered connections	
Gate valves	2 in and smaller	125-lb, bronze, nonrising stem, soldered ends	
	2½ in and larger	125-lb, cast iron, nonrising stem, flanged ends	

Item	Pipe size	Description	Reference standards
Check valves	2 in and smaller	125-lb, bronze, swing check, renewable bronze disc and plugs, solder end connections	
	2½ in and larger	125-lb, cast iron swing check, bolted cap, renewable discs and plugs, flanged ends	
Balancing valves	2 in and smaller	250-lb, bronze body, Teflon seats and seals, solder ends	
Gaskets	All	Nonasbestos with synthetic fibers and SBR binder, full face on flat face flanges	

Services:

Domestic Water, Underground
 Potable Water
 City Water, "Underground"

Item	Pipe size	Description	Reference standards
Pipe	4–24 in	Ductile cast iron, mechanical joint, 250 psi rated, 18-ft lengths, class 52, cement lining	ANSI/AWWA, C151 A21.51
Joints	All	Bolted mechanical joints	ANSI/AWWA, C104/A21.4
Fittings	4–24 in	Ductile cast iron, 250 psi pressure rated, mechanical joint with glands, bolts, and gaskets	ANSI/AWWA, C110/A21.10, and ANSI/AWWA, C111/A21.11
		Cement lining	ANSI/AWWA C104/A21.4
Joint restraint and anchors	All	Ductile iron set-screw retainer glands on joints at all directional changes and at dead ends, also at tees, hydrants, and valves Alternate: Tie rods and nuts or Victaulic style 37	
Thrust blocks		Thrust blocks must be provided in addition to retainer glands and/or tie rods	

Item	Pipe size	Description	Reference standards
Valves	hydrants	5¼-in main valve, 6-in mechanical joint inlet connection, one (1) 4½-in pumper connection, two (2) 2½-in hose connections, automatic drains and bronze pentagon operating nut, measuring 1½-in point to flat	
	6-in hydrant shutoff valves	Mechanical joint, gate pattern, square operating nut, nonrising stem with curb box. Valve to be located within 5 ft of hydrant served.	AWWA C111-53
Valve box (4) (curb box)		Cast iron, 2-piece telescoping, screw adjustable for depth. Cover to be loose type with water cast iron top. Provide one (1) crowfoot wrench for every (6) valves with curb boxes; painted	
Valves	4–12 in	Bronze-mounted gate valve with mechanical joint ends, nonrising stem, parallel seats and operating nut. W.P. 175# nonshock, cold water, UL listed, FM approved	AWWA C111-53
	4–12 in	Bronze-mounted 125# flanged gate valve, nonrising stem, parallel seats and operating nut, W.P. 150# nonshock, cold water, UL listed, FM approved	ANSI A21.11
	14–24 in	Iron, gate valve with mechanical joint ends, nonrising stem, inside screw parallel seats, double disc, W.P. 150# cold water	ANSI 21.11, AWWA C-111
	14–24 in	Iron, gate valve with 125# flanged ends, nonrising stem inside screw, parallel seats, double disc, W.P. 150# cold water	ANSI 21.11 AWWA C500

Item	Pipe size	Description	Reference standards
Flanges	4–24 in	125# flat faced flange	Ductile iron, ANSI A21.10
Boltings (for ANSI mechanical joints)		Tee head bolts with heavy hex nuts	High-strength corrosion-resistant alloy
(for ANSI flanged joints)		Hex head machine bolts with heavy hex nuts	ANSI B16.1
Gaskets (for ANSI mechanical joints)		Plain rubber	Clow #F-1950
(for ANSI flanged joints)		150# FF service gasket to 12 in	Clow #F-1950

Services:

Storm Water Drainage Interior Aboveground

Pressure/Temperature Limits: Gravity drainage/140°F, PVC Only—120°F

General Materials: Cast Iron, PVC

Item	Pipe size	Description	Reference standards
Pipe	2–15 in	Cast iron, soil pipe, service weight hub and spigot	ASTM A 74
		No-hub cast iron soil pipe	CISPI 301
		PVC plastic drainage pipe Sch. 40	ASTM D 2665
Fittings		Cast iron hub and spigot	ASTM A 74
		No-hub cast iron fittings	CISPI 310
		PVC socket-type fittings	ASTM D 2665
Joints		Poured lead and oakum	ASTM B 29
		No-hub compression coupling, stainless steel cover and neoprene gasket	CISPI 310
		PVC solvent cement	

 Service:

Storm Drainage “Underground”

Item	Pipe size	Description	Reference standards
Pipe	3–12 in	XH (extra-heavy) cast iron, plain end hub and spigot soil pipe	ASTM A 74
	12–30 in	Reinforced concrete, bell and spigot	ASTM C 76, Class IV, Wall B
Fittings	3–15 in	XH (extra-heavy) cast iron, plain end hub and spigot soil fittings	ASTM A 74
	15–30 in	Reinforced concrete, bell and spigot	ASTM C 76, Class IV, Wall B
Gaskets	3–15 in (for cast iron joints)	One-piece neoprene compression gasket	ASTM C 564
	15–30 in (for concrete joints)	Push-on rubber O ring	ASTM C 443

 Services:

Above Ground Interior
 Natural Gas
 Propane
 Mixed Gas

Pressure Limit: Medium Pressure up to 20 psig

General Materials: Carbon Steel, Iron, Brass

Item	Pipe size	Description	Reference standards
Pipe	All	Sch. 40 welded black steel	ASTM A 53
	Up to 1½ in	Copper tubing type G	ASTM B 837
Joints	3 in and smaller	Screwed	
	4 in and larger	Welded	
	Copper pipe	Soldered	
Fittings	3 in and smaller	Screwed malleable iron	ANSI B 16.3
	4 in and larger	Steel butt weld	ANSI B 16.9
	Fittings	Wrought copper	ASTM B 16.22
Joining materials	3 in and smaller	Teflon tape or paste, Du Pont	
	4 in and larger	Welded	
Valves	1 in and smaller	Brass squarehead gas cocks	
	Larger than 1 in	Steel lubricated plug gas cocks	

Service:

Below Ground Fuel Gases, 1- to 12-in sizes; Natural Gas, Propane, Mixed Gases

Pressure/Temperature Limits: 100 psig, Ambient

General Materials: Steel, PE

Item	Pipe size	Description	Reference standards
Steel pipe	All	Black steel, Sch. 40, with shop or field-applied coating	ASTM A 53 Grade B
Pipe coating		Shop coating of extruded PE, min. 36 mils thickness, with adhesive undercoat	Type 1, Fed. Spec. L-C-530
		Shop coating of thermoset epoxy, mm. 10 mils thick	Type 2, Fed. Spec. L-C-530
		Coal tar enamel 0.129 in thick with felt or fiberglass wrap, mm. 120 mils thick	AWWA C 203
		Field-applied plastic tape, min. 10 mils thick	Fed. Spec. L-T 1512, Type 1
Fittings		Welded steel	ANSI B 16.11
		Threaded steel	None
		Dresser	ANSI B 16.5
		Flanged steel	
Joints		Welded	API-1104
		Threaded	ANSI B 2.1
		Flanged	ANSI B 31.8
		Mechanical	AWWA C 111/A 21.11
Plastic pipe and fittings		High-density PE, SDR 13.5 Black, grades 2306, 3306 or 3408	ASTM D 2513
Joints		Butt heat fusion (preferred) or other mechanical couplings approved by manufacturer	
Valves	All	Lubricated plug type, high head extension, dresser or flanged end min. rating 175 psig wog	

Service:

Sanitary Soil and Vent (Above Ground)

Pressure/Temperature Limits: Atmospheric/Ambient*General Materials:* Cast Iron

Item	Pipe size	Description	Reference standards
Pipe	All	Service-weight cast iron soil pipe	ASTM A 74 OR
		No-hub cast iron soil pipe	CISPI 301
Joints	All	Poured lead and oakum, bell and spigot ends OR No-hub, plain end OR Puch-on, bell and spigot ends	AWWA C 111/ ANSI A 21.11
Fittings	All	Cast iron hub and spigot fittings OR Cast iron no-hub fittings	CISPI 310
Joining materials	All	Molten lead and oakum fiber packing, plumbing grade OR No-hub neoprene gasket with CISPI Series 310 stainless steel shield and retaining clamps OR Neoprene compression gasket	ASTM B 29

Service:

Sanitary Drainage "Underground"

Item	Pipe size	Description	Reference standards
Pipe	2–15 in	Service-weight cast iron, plain end, hub and spigot soil pipe	ASTM A 74
Fittings	2–15 in	Service-weight, plain end, hub and spigot-type soil fitting	ASTM A 74
Gaskets	3–15 in	Neoprene, one-piece compression gasket	ASTM C 443

Services:

Nonsanitary Waste and Vent (Above Ground) Other Than Laboratories

Pressure/Temperature Limits: Atmospheric/120°F*General Materials:* Copper, Carbon Steel, Cast Iron

Item	Pipe size	Description	Reference standards
Pipe	2½ in and smaller	DWV seamless copper drainage tube, hard drawn	ASTM B 306
	3 in and larger	Sch. 40 welded carbon steel, galvanized No-hub cast iron soil pipe	ASTM A 120 CISPI 301
Joints	2½ in and smaller	Soldered	
	3 in and larger	Screwed, threaded ends No-hub, plain end	
Fittings	2½ in and smaller	Cast and wrought copper DWV fittings	ANSI B 16.23
	3 in and larger	Galvanized cast iron threaded drainage fittings	ANSI B 16.12
		Cast iron no-hub fittings	CISPI 310
Joining materials	2½ in and smaller	95/5 (tin/antimony) solder	ASTM B 32
	3 in and larger	Teflon tape or paste No-hub neoprene gasket with CISPI Series 301-85 stainless steel shield and retaining clamps	

 Services:

Nonsanitary Waste and Vent (Above Ground) Other Than Laboratories

Pressure/Temperature Limits: Atmospheric/120°F

General Materials: Copper, Carbon Steel, Cast Iron

Item	Pipe size	Description	Reference standards
OR			
Pipe	1½–4 in	PVC Sch. 40	ASTM D 2665
Fittings	1½–4 in	Socket solvent joints	ASTM D 2665
Joining materials	All	Solvent/cement	ASTM D 2855

 Service:

Slurry System

Pressure/Temperature Limits: 100 psig at 75°F

General Materials: Copper

Item	Pipe size	Description	Reference standards
Pipe	All	Hard-drawn seamless copper tubing, type K	ASTM B 88
Joints	All	Soldered	
Fittings	All	Wrought copper	ANSI B 16.23

Service:

Sump Pump and Sewage Ejector Pump Discharge (Above Ground)

Pressure Limit: 125 psig Ambient*General Materials:* Carbon Steel, Ductile Iron

Item	Pipe size	Description	Reference standards
Pipe	All	Sch. 40 carbon steel, galvanized	ASTM A 53, Grade B
Joints	All	Threaded end	ASTM B 2.1
Fittings	All	Galvanized cast iron threaded drainage fittings	ANSI B 16.12
Joining materials	All	Teflon tape or paste	
Gate valves	2 in and smaller	125-lb, bronze, nonrising stem, soldered ends	
	2½ in and larger	125-lb, cast iron, nonrising stem, flanged ends	
Check valves	2 in and smaller	125-lb, bronze, swing check, renewable bronze disc and plugs, soldered end connections	
	2½ in and larger	125-lb, iron body, bronze disc and seat, flanged ends	

Service:

USP Purified Water Feedwater

Pressure/Temperature Limits: 100 psig at 180°F*General Materials:* Polypropylene

Item	Pipe size	Description	Reference standards
Pipe	All	Sch. 40 virgin unpigmented pipe grade polypropylene specifically for deionized water	ASTM D 2146, Type I
Joints	All	Heat-fusion butt welded	
Fittings	All	Sch. 40 virgin unpigmented pipe, grade polypropylene heat-fusion pipe fittings	ASTM D 2146
Valves	All	150-lb, polypropylene body, ball and stem compatible with pipe, socket-welded ends	
OR			
Pipe and fittings	All	Type 316L sanitary tubing 0.065 wall thickness with square ends. Fittings shall be long turn for machine welding with 240 grit finish, electropolished.	ASTM A 270
Joints	All	Automatic machine butt weld. All equipment shall be joined with sanitary clamp type similar to Tri-Clover, Inc. Clamp shall be 304SS with metal wing nut or SS bolts depending on size.	
Valves	All	Diaphragm, wier type, clamp ends Type 316L, 150 psig rated top entry sanitary diaphragm of Grade R-2 Teflon, finish same as pipe.	

Service:

Diesel Engine Exhaust

Pressure/Temperature Limits: 5 psig at 1000°F*General Materials:* Carbon Steel

Item	Pipe size	Description	Reference standards
Pipe	All	Sch. 20 welded carbon steel	ASTM A 53, Grade A
Joints	All	Welded	
Fittings	All	Butt weld, carbon steel, beveled end, long radius, with thickness to match pipe	
		For drain piping, use 3000-lb forged steel socket weld connections.	ASTM A 105
Flanges	All	125/150 lb. forged steel, slip-on	
Flange bolting	All	Alloy, steel bolt studs, thread full length	ASTM A 193, Grade B7
		Heavy hex nuts	ASTM A 194, Class 2H ANSI B 18.2
Drain valves	All	Forged steel gate valves, solid wedge, bolted bonnet and gland, OS&Y, socket weld connections, Vogt Figure SW12111	ASTM A 105, Grade 1
Gaskets	All	Garlock style 1000	

Service:

Vacuum Cleaning Systems

Pressure/Temperature Limits: 10 in Hg Vacuum/Ambient*General Materials:* Zinc-Coated Steel

Item	Pipe size	Description	Reference standards
Tubing	2½ in and larger	No.16 gauge minimum zinc-coated steel	
Joints	All	Sealed joints with heat-shrink sleeves	
Fittings	All	Galvanized steel, long-radius type, with expanded ends	
Joining materials	All	Heat-shrink sleeves	
Valves	2 in	Nickel-plated ball valve forged brass type D	Spencer Turbine
	4–12 in	125# FF blast gate, cast iron body, SS shaft C/S shutter	

Service:

Refrigerant Piping Systems

Pressure/Temperature Limits: 225 psig at 115°F (Condensing)*General Materials:* Copper

Item	Pipe size	Description	Reference standards
Pipe	2 in and smaller	Seamless copper air-conditioning and refrigeration tubing, type ACR, hard drawn	ASTM B 280
Joints	2 in and smaller	Soldered or brazed	
Fittings	2 in and smaller	Wrought copper solder joint pressure fittings or wrought copper brazing fittings	ANSI B 16.22

Item	Pipe size	Description	Reference standards
Joining materials	2 in and smaller	Solder, 95/5 (tin/antimony) brazed silver solder, AWS Classification BCuP5 alloy (15% silver, 5% phosphorous, 80% copper) Silfos 15 by Handy and Harmon; Flux, Handy Flux by Handy and Harmon	ASTM B 32, Alloy, Grade 95TA or ANSI/AWS A5.3
Shutoff valves	2 in and smaller	Diaphragm type, forged brass body and bonnet, positive backseating when fully open, raised seat with nylon seat disc, stainless steel spring, flared or soldered connections, soldered connections with extended ends, UL listed	
Check valves	2 in and smaller	Forged brass body, Teflon seat, guided piston, stainless steel spring, accessible internal parts, operable in all positions. Rated for 300°F and 500 psig.	
Relief valves	2 in and smaller	Automatic, forged brass body, reseating characteristics, stem guide, factory sealed, ASME constructed and certified.	

Services:

- Process Waste and Vent (Above Ground)
- Solvent Waste and Vent (Above Ground)
- Oxidizable Waste and Vent (Above Ground)
- Isolation Waste and Vent (Above Ground)
- Lab Waste and Vent (Above Ground)

Pressure/Temperature Limits: Atmospheric/Ambient

General Materials: Borosilicate Glass

Item	Pipe size	Description	Reference standards
Pipe	All	Borosilicate glass	ASTM E 438-83
Joints	All	Compression couplings (bead-to-bead and bead-to-plain-end compression couplings)	
Fittings	All	Compression coupling fittings	
		OR	
Pipe and fittings	All	Flame-retardant polypropylene, Sch. 40	
Joints	2 in and smaller	Proprietary mechanical-screwed	
	2½ in and larger	Socket, heat-fused joint	
		OR	
	2–10 in	Bell and spigot	Silicon iron, ASTM A 518 Duriron Co.
Fittings	2–10 in	Bell and spigot floor and drainage fittings	Silicon iron, ASTM A 518 Duriron Co.
Joints		Caulked	
Joint packing		Acid resistant, asbestos free	Oakum No. 312 sealtite red stripe or BMS approved equal

 Service:

 Process Drainage “Underground”

Item	Pipe size	Description	Reference standards
Pipe	3–15 in	Plain end, hub and spigot soil pipe, Tyler pipe or equal	XH (extra-heavy) cast iron, ASTM A 74
Fittings	3–15 in	Plain end, hub and spigot, soil fitting	XH (extra-heavy) cast iron, ASTM A 74
Gaskets	3–15 in	Plain end, hub and spigot, soil fitting	XH (extra-heavy) cast iron, ASTM A 74
Gaskets	3–15 in	One-piece compression gasket	Neoprene, ASTM C 443

 Service:

Severe Service Biohazard Waste and Vent System

Pressure/Temperature Limits: 75 psig at 280°F

General Materials: Polyvinylidene Fluoride (PVDF)

Item	Pipe size	Description	Reference standards
Piping	1–4 in	Unpigmented, natural tube, polyvinylidene fluoride (PVDF) pipe	ASTM D 1785
Joints	1–4 in	Socket heat-fusion welded	ASTM D 2657
Fittings	1–4 in	Unpigmented, natural PVDF, socket-fusion	ASTM D 2467

Service:

Ordinary Service Biohazard Waste and Vent System

Pressure/Temperature Limits: Atmospheric/Ambient*General Materials:* Chlorinated Polyvinyl Chloride (CPVC)

Item	Pipe size	Description	Reference standards
Piping	All	Sch. 80 chlorinated polyvinyl chloride (CPVC) pipe	ASTM F 441
Joints	All	Socket solvent cement	
Fittings	All	Sch. 80 CPVC, socket ends	ASTM F 439
Primer for solvent cement	All	Recommended by manufacturer	
Solvent cement	All	Do	ASTM F 493

Services:

Compressed Medical, Laboratory, and Process Gases and Vacuum:

Vacuum, Nitrogen, Compressed Air, High-Pressure Compressed Air, and Cylinder Gases

Carbon Dioxide

Pressure/Temperature Limits:

100 psig/Ambient (Breathing Air)

29 in Hg/Ambient (Vacuum)

200 psig/Ambient (Nitrogen and Compressed Air)

General Materials: Copper, Carbon Steel

Item	Pipe size	Description	Reference standards
Pipe	4 in and smaller	Seamless copper tubing, Type L, hard drawn	ASTM B 88, Grade B
	High pressure gases	Type K copper tubing	
	4 in and larger (process only)	Sch. 40 seamless carbon steel	ASTM A 53
	4 in and smaller	Brazed	AWS 5.2
Joints	4 in and larger (process only)	Welded connections	

Item	Pipe size	Description	Reference standards
Fittings	2 in and smaller	Wrought copper brazed fittings	ANSI B 16.22
	3 in and larger	Standard seamless steel, butt welded	ASTM A 234, Grade WPB
Joining materials	All	15% silver solder, AWS classification BCuP5 alloy (15% silver, 5% phosphorous, 80% copper)	ANSI/AWS A 5.3
Ball valves	1/2-3/4 in	150-lb, bronze, three-piece ball valve	
	1-2 in	150-lb, bronze serviceable in-line, quarter turn, lever operated, 3 piece, full port, threaded connections	
	2 1/2-4 in	400-lb, bronze body ball valve, chrome-plated bronze ball, full flow with Teflon seats and double Teflon stem seal	
Pressure-regulating valves	1/4-1 in	400-lb maximum inlet pressure rated, standard relieving diaphragm, pressure adjustment range 5 to 125 psig, zinc body, aluminum bonnet and brass valve assembly with pressure gauge (0-160 psig)	
Gaskets	All	Homogeneous nitrile rubber, full face for flat face flanges	

Service:

Cryogenic Liquid

Pressure/Temperature Limit: 150 psig at -320°F*General Materials:* Preinsulated Copper

Item	Pipe size	Description	Reference standards
Pipe and fittings	Up to 2 in	Preinsulated, type K copper tubing, hard drawn. 3-in polyurethane foam insulation with minimum 0.06-in PVC jacket	ASTM B 88
Joints	All	Soldered, 45% silver	
Ball valves	All	Cryogenic, extended stem, screwed end, bronze body, stainless steel ball	

 Service:

Cylinder Gases, Pharmaceutical Use, High Purity

Pressure/Temperature Limits: 100 psig/Ambient

General Materials: Stainless Steel

Item	Pipe size	Description	Reference standards
Pipe	All No. 4 finish	304L or 316L stainless steel tube 180 grit electropolished I.D., no. 4, mill finish O.D.	ASTM A 270
Joints	All	Machine orbital welded	
Fittings	All	304L or 316L stainless steel tube welded fitting, 180 grit electropolished I.D., mill finish O.D.	
Valves	All	Ball valve, 150-lb, 304L or 316L SS, stainless steel serviceable in- line, quarter turn, lever operated, 3 piece, full port, butt-welded connections, oxygen cleaned	ASTM A 351
OR			
Diaphragm valve, wier type			

 Service:

Reverse-Osmosis Water

Pressure/Temperature Limits: 100 psig at 180°F*General Materials:* Polypropylene

Item	Pipe size	Description	Reference standards
Pipe	All	Type 1, Sch. 80, unpigmented polypropylene	ASTM D 2146
Joints	All	Heat-fusion welded	
Fittings	All	Type 1, Sch. 80, polypropylene, socket ends, heat-fusion welded	ASTM D 2146
Flanges	All	150-lb, socket ends	ASTM D 2146
Gaskets	All	Viton	
Couplings and adapter couplings	All	Type 1, Sch. 80, polypropylene, socket ends or socket-to-thread ends	ASTM D 2146
Ball valves (balancing and shutoff)	All	150-lb, Type I polypropylene body, ball and stem compatible with pipe, socket-welded ends, true union design, Hayward True Union Series	ASTM D 2146
Check valves	All	Type 1 polypropylene, body, true union ball type, Viton or EPDM O-ring seals and seat, socket connection, Nibco Ball Check Valve	ASTM D 2146

Service:

Distilled, Deionized, USP Purified
USP, up to 2-in Pipe Size Only

Item	Pipe size	Description	Reference standards
Pipe	½–2 in	Stainless steel, Sch. 10S welded	Type 316, ASTM A 312
	¼ in and smaller	Stainless steel, Sch. 40S seamless	Type 316, ASTM A 312
Fittings	½–2 in	Stainless steel, Sch. 105 butt weld	Type 316, ASTM A 403
	¼ in and smaller	Forged stainless steel, screwed end	ASTM A 182 F316
Flanges		Forged stainless steel, 150# slip-on or raised face well neck	ASTM A 182 F-316L
Gaskets	All sizes	Teflon and neoprene, 1 50# envelope with neoprene insert	
Bolting	All sizes	Stainless steel, stud bolts	
	All sizes	Stainless steel, hex nuts	
Valves	2 in and smaller	Stainless steel, butt weld ball reinforced Teflon seats, solid ball	Type 316

Service:

Chlorichlorinated Distilled, Deionized, USP Purified
USP, up to 2-in Pipe Size Only

Item	Pipe size	Description	Reference standards
Sanitary fittings		Stainless steel, Sch. 5 or tube size, clamped fittings	Type 316L
Gauges		Stainless steel, Sch. 10 butt welded, diaphragm and Teflon for all wetted parts, filled with high-temperature silicone	Type 316

 Service:

Water for Injection

Up to 2-in Pipe Size Only

Item	Pipe size	Description	Reference standards
Tubing	½–2 in	Welded stainless steel, 0.065-in wall thickness, interior polished to 180 grit min., manufactured to 3A standard	Type 316L, ASTM A-270
Fittings	½–¾ in	Stainless steel, ½-in O.D. × 0.065-in wall thickness	Type 316L, ASTM-270
		¾-in × 0.065-in wall thickness, 180 grit polished I.D. min. Manufactured to 3A standard. Fittings must have extended ends for automatic welding	Type 316L
Sanitary fittings	1–2 in	Stainless steel, Sch. 5 or tube size, clamped fittings	Type 316L
Gauges		Stainless steel, Sch. 10 butt welded, diaphragm, filled with high-temperature silicone	Type 316
Gaskets	½ in		Use Vexel No. VL40T, 0.757 O.D.
	1–2 in	Standard molded, one-piece gasket Teflon envelope	
Joints	½–¾ in	Stainless steel, 2-in long male ferrule and 2-in long female ferrule. 180 grit polished I.D. min.	Type 316L
	1–2 in	Stainless steel, manufactured to 3A standards, 3-in long ferrule butt weld, Type 180, grit polished I.D. min.	Type 316L

Item	Pipe size	Description	Reference standards
Valves	1/2–2 in	Ball valve 316L stainless steel body with tube ends of 0.065-in wall thickness, ball and stem 316 stainless steel externals (nuts, bolts, etc.). Reinforced Teflon seats and S-gasket body seals. Valves to be passivated interior of valve and ball, to be polished to 180 grit.	
		OR	
		For use where tubing spec is not practicable or not adaptable to existing plant, butt-welded WFI Systems.	
Pipe	1/2–2 in	Stainless steel, Sch. 10S welded	Type 316, ASTM A-312
	1/4 in	Stainless steel, Sch. 40S seamless	Type 316, ASTM A-312
Fittings	1/2–2 in	Stainless steel, Sch. 10S butt weld	WP-316, ASTM A-403
	1/4 in	Forged stainless steel, screwed	ASTM A-182-F316L
Flanges		Forged stainless steel, 150# slip-on or RF weld neck	ASTM A-182-F316L
Gaskets	All sizes	150# envelope, Teflon and neoprene, with neoprene insert	
Bolting	All sizes	Stainless steel, stud bolts	
	All sizes	Stainless steel, hex nuts	
Valves	1/2–2 in	Stainless steel, reinforced Teflon seats, S-gasket body seals and solid balls, butt weld ball, with 4-in stainless steel extension	Type 316
Sanitary fittings		Stainless steel, Sch. 5 or tube size clamped fittings	Type 316L
Gauges		Stainless steel, Sch. 10 butt-welded, diaphragm, Type SM	Type 316, and Teflon for all wetted parts, filled with high-temperature silicon

 Service:

Deionized Water

PVC Piping (Polyvinyl Chloride)

Item	Pipe size	Description	Reference standards
Pipe	¼–3 in	PVC, Sch. 80, Type 1, plain end	Grade 1
Fittings	¼–3 in	PVC, Sch. 80 socket type ends	
Unions	¼–3 in	PVC, unions, socket type ends for solvent cementing and Viton O rings, Sch. 80	ASTM D-2467 and ANSI B2.1
Flanges	½–3 in	PVC, socket type flanges for solvent cementing, Sch. 80, 150#, F.F.	ASTM D-2467
Bolting		Heavy hex head machine bolts with heavy hex nuts and flat C/S washers	ASTM A-307, Grade B
Gaskets		150#, ⅛-in thick Gylon full face, ANSI dimensions	
Valves	½–3 in	PVC, ball valve socket ends, 150#, one-quarter turn	Type 1, Grade 1, ASTM D-1784
	½–3 in	PVC, check valve, socket ends, 150#, with Viton O rings	Type 1, Grade 1, ASTM D-1784
	½–3 in	PVC, diaphragm valve socket ends (Teflon diaphragm) with standard weir-type bonnet assembly	Type 1, Grade 1

Note 1: PVC adapters shall be used at all threaded connections.