

## Basis of Design

This section applies to the design and installation of pipe, pipe fittings, valves, piping accessories and equipment for plumbing and HVAC systems including potable and laboratory hot and cold water, heating water, cooling water, steam and condensate, HVAC equipment, sanitary and storm drains, rainwater leaders, compressed air, vacuum and gases.

### Design Criteria

- Generally, use the following systems for all piping installations. Other systems may be used with coordination and approval by Campus Engineering. Piping installation referenced shall be inside of building to five feet exterior of the building envelope. Outside piping: Refer to Civil sections for utilities.
- No mechanical joints for pressurized piping in pipe shafts.
- Design piping to allow for ample movement and flexibility for expansion and contraction due to temperature changes.
- Provide a service header for every service entering a building. Provide a shutoff valve in the service header piping immediately upon entry into the building. Install all meters, strainers, pressure reducing valves, backflow preventers, major branch connections, etc. at the service header. Provide bypass connections at the service header so that service to the building is continuous when maintenance is performed on the various components.
- Provide valves to permit isolation of portions of the building piping systems for maintenance, alterations, and repair work without shutting down entire systems.
- Provide individual shutoff valves to isolate all equipment from the piping system including pumps, coils, fixtures, fume hoods, bio-safety cabinets, and autoclaves.
- The following table lists typical piping systems with its corresponding symbol, and pipe codes to reference subsequent Products, Materials and Equipment tables. See also Facilities Services Design Guide – Mechanical sections - Water Treatment and Flushing, Plumbing Pressure Testing and HVAC and HVAC Piping Pressure Testing.
- Example: Potable Cold Water; symbol CW, and pipe code P-1
  - 1) Pipe code table P-1 lists a maximum operating pressure of 100 lb/in<sup>2</sup> and maximum operating temperature of 70° F.
  - 2) Facilities Services Design Guide – Mechanical - Plumbing Pressure Testing lists the recommended test pressure of 150lb/in<sup>2</sup>. Facilities Services Design Guide – Mechanical - Water Treatment and Flushing lists the recommended cleaning method of water flush.

Piping System	Symbol	Pipe Code
Acid Resistant Vent	ARV	P-3
Acid Resistant Waste	ARW	P-3
Carbon Dioxide	CO2	P-1
Central Cooling Water	CCW	P-4
Coil Condensate	CD	P-1
Compressed Air (Laboratory)	A	P-1

<b>Piping System</b>	<b>Symbol</b>	<b>Pipe Code</b>
Compressed Air (Pneumatic)	CA	P-1
Condenser Water	CNDW	P-1
Fire Protection	F	P-10
Heating Hot Water	HHW	P-1
Helium Recovery	HR	P-1
Irrigation, Inside Building	I	P-1
Irrigation, Outside Building	I	P-9
Laboratory Cold Water	LCW	P-1
Laboratory Hot Water	LHW	P-1
Laboratory Hot Water Circulation	LHWC	P-1
Laboratory Vacuum	LV	P-1
Lake Water	LW	P-9
Medical Gas	MG	P-8
Medical Vacuum	MV	P-8
Natural Gas	G	P-5
Nitrogen	N	P-1
Oxygen	O	P-8
Potable Cold Water	CW	P-1
Potable Hot Water	HW	P-1
Potable Hot Water Circulation	HWC	P-1
Process Chilled Water	CHW	P-1
Propane	P	P-5
Refrigerant Liquid	RL	P-7
Refrigerant Suction	RS	P-7
Reverse Osmosis/De-ionized Water (High Purity)	DI	P-6
Roof Drain (Rain Leader)	RD	P-2
Sanitary Vent	V	P-2
Sanitary Sewer	SS	P-2
Sea Water	SW	P-9
Steam (Low Pressure)	LPS	P-4
Steam (Medium Pressure)	MPS	P-4
Steam (High Pressure)	HPS	P-4
Steam Condensate	CNDS	P-4
Storm Drain	SD	P-2
Tempered Potable Water (Safety Shower/Eyewash)	TW	P-1
Trap Primer	TP	P-1
Well Water	VV	P-9

## Design Evaluation

The following information is required to evaluate the design:

- Programming Phase: Provide a statement of design intent describing piping systems to be used.
- Schematic Design Phase: Provide a basis of design narrative. Provide preliminary location of utility connection(s), header(s), pipe chase(s), fixture(s), pipe legend, and outline specifications. See Mechanical: Commissioning section for items to be included in the basis of design.
- Design Development Phase: Provide piping layout plans, controller and header locations, header diagrams, utility connection locations and sizes, and outline specifications.
- Construction Document Phase: Provide complete pipe layout and sizes, valve and accessory locations and sizes, utility points of connection and invert elevations, individual riser diagrams for all piping systems (Chilled Water, Central Cooling Water, Condenser Water, Heating Hot Water, Potable and Nonpotable Water, Wastes and Acid Resistant Wastes, Rainleaders, RO/DI, etc.), piping diagrams and details, water header diagram, enlarged mechanical plans where necessary, section drawings detailing underground piping and congested areas showing coordination with equipment from other trades (e.g. above corridors), details for special applications, design calculations, final basis of design (to be used by Test Engineer for Commissioning), and final specifications. If a specification is stated as a function of the "operating pressure", the operating pressure for that system must be given in the specifications.

## Construction Submittals

- Provide industry standard submittal information for piping, valves and accessories.

## Related Sections

- Facilities Services Design Guide – Mechanical - General Requirements
- Facilities Services Design Guide – Mechanical - Plumbing
  - Potable and Non-potable Water
  - Waste and Drains
  - Acid and Laboratory Wastes
  - Compressed Air, Vacuum, Natural Gas & Nitrogen
  - RO/DI
  - Plumbing Pressure Testing
- Facilities Services Design Guide – Mechanical - Heating, Ventilating and Air Conditioning
  - Process and Environmental Chilled Water
  - Central Cooling Water
  - Steam and Condensate

- Hydronic Heating
- Refrigeration
- Coils
- HVAC and HVAC Piping Pressure Testing
- Facilities Services Design Guide – Mechanical - Hangers and Supports
- Facilities Services Design Guide – Mechanical - Pumps
- Facilities Services Design Guide – Mechanical - Metering and Gauges
- Facilities Services Design Guide – Mechanical - Nonstructural Component Seismic Design
- Facilities Services Design Guide – Mechanical - Identification
- Facilities Services Design Guide – Mechanical - Insulation
- Facilities Services Design Guide – Mechanical - Water Treatment and Flushing
- Facilities Services Design Guide – Mechanical - Noise and Vibration Control
- Environmental Health & Safety Design Guide – Sprinkler Protection & Standpipes
- Facilities Services Design Guide – Mechanical - Testing, Adjusting and Balancing
- Facilities Services Design Guide – Mechanical - Commissioning
- Facilities Services Design Guide – Civil - Irrigation

**Products, Material and Equipment**

**Pipe**

- Use industry standards for piping systems specified and comply with the following additional requirements:
- The following tables list the typical service piping, standard operating pressures and temperatures, recommended testing pressures.

<b>PIPE CODE P-1</b>		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Carbon Dioxide (CO)	Varies	-
Coil Condensate (CD)	40	60
Compressed Air – Laboratory (A)	100	100
Compressed Air – Pneumatic (CA)	100	100
Condenser Water (CNDW)	40	85
Heating Hot Water (HHW)	Varies	190
Helium Recovery (HR)	Varies	-
Irrigation, Inside Building (I)	100	70
Laboratory Cold Water (LCW)	100	70
Laboratory Hot Water (LHW)	100	160

Laboratory Hot Water Circulation (LHWC)	100	160
Laboratory Vacuum (LV)	-29 in-Hg	100
Nitrogen (N)	Varies	-
Potable Cold Water (CW)	100	70
Potable Hot Water (HW)	100	160
Potable Hot Water Circulation (HWC)	100	160
Process Chilled Water (CHW)	Varies	60
Tempered Potable Water (TW)	100	80
Trap Primer (TP)	100	70
Sizes	½-inch and larger	
Pipe	Above grade: Copper Type L; Below grade: Copper Type K or ductile iron; CHW & HHW above grade: 2½-inch and larger, black steel. Schedule 40 Irrigation outside: See remarks. Nitrogen piping: All fittings/joints shall be cleaned as for medical gas service (NFPA 99); piping shall be cleaned and capped ACR type.	
Wall Thickness	Standard Weight	
Valves	Single piece, full flow ball style.	
Remarks	Irrigation: Refer to Civil – Irrigation section. LV: Branch piping section outlet shall connect to top of main. Nitrogen piping system shall be brazed under a nitrogen purge. Victaulic ok only for 2-1/2" and larger CW, LCW, and F piping	

<b>PIPE CODE P-2</b>		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Roof Drain (RD)	N/A	N/A
Sanitary Vent (V)	N/A	N/A
Sanitary Sewer (SS)	N/A	N/A
Storm Drain (SD)	N/A	N/A
Sizes	All	
Pipe	Above grade: Cast Iron CISPI 301, no hub; Below grade: Cast Iron CISPI 301, hub & spigot. Roof drains shall be cast iron.	
Wall Thickness	Standard Weight	
Remarks	Above grade force main & force main-vent same as pipe code P-4. Minimum test pressure: 125 lb/in <sup>2</sup> . Below grade: Refer to Civil sections for utilities.	

PIPE CODE P-3		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Acid Resistant Vent (ARV)	N/A	N/A
Acid Resistant Waste (ARW)	N/A	N/A
Sizes	All	
Pipe	Above grade: Polypropylene; pigmented, flame retardant Below grade: Polypropylene; pigmented, non-flame retardant	
Wall Thickness	Schedule 40	
Remarks	Above grade: Fusion joints. Below grade: Fusion joints. Within laboratory casework (accessible): Mechanical joints allowed at the connection to the plumbing fixture.	

PIPE CODE P-4		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Central Cooling Water (CCW)	180	60
Steam (LPS)	15	259
Steam (MPS)	60	338
Steam (HPS)	185	388
Steam Condensate (CNDS)	Varies	-
Sizes	All	
Pipe	Black steel	
Wall Thickness	LPS and CCW, Schedule 40, 12 inch and larger Standard Weight; CCW 2-inch and larger, Schedule 80; MPS, HPS, and CNDS, Schedule 80.	
Valves	CCW 2½-inch and larger, butterfly, steel lugged style; HPS 2-inch and larger, high performance butterfly valve, steel lugged style, with manual gear operator, Neles/Jamesbury Series 815L/830L. Building isolation valves for 2-inch and larger for CCW, HPS, MPS< and LPS, high performance butterfly valve, steel lugged style, with manual gear operator, Neles/Jamesbury Series 815L/830L.	
Remarks	2-inch and smaller: Threaded forged fittings; 2½-inch and larger: Butt weld type forged fittings; All steam raised faced flanges, with spiral wound gasket.	

<b>PIPE CODE P-5</b>		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Natural Gas (G)	5	-
Propane (P)	5	-
Sizes	All	
Pipe	Black steel	
Wall Thickness	Schedule 40	
Remarks	Above grade: 2-inch and larger butt-welded fittings; 2-inch and smaller threaded fittings allowed. Below grade: Refer to Civil sections for utilities. See EH&S Laboratory Safety Design Guide regarding lab emergency gas shut-off valves.	

<b>PIPE CODE P-6</b>		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Reverse Osmosis/De-ionized Water (DI)	100	70
Sizes	All	
Pipe	Polypropylene – non-pigmented	
Wall Thickness	Schedule 40	
Valves	Union body, full port, ball style	
Remarks	Electric fusion joints. Piping shall be continuously supported.	

<b>PIPE CODE P-7</b>		
Service	Max Operating Pressure lb/in <sup>2</sup> gage	Max Operating Temp Deg F
Refrigerant Suction (RS)	High Side: 250	150
Refrigerant Liquid (RL)	Low Side: 90	70
Sizes	½-inch and larger	
Pipe	Copper, ACR type	
Wall Thickness	Standard Weight	
Remarks	No flared connections and fittings. Braze piping under nitrogen purge.	

<b>PIPE CODE P-8</b>		
Service	Max Operating Pressure lb/in2 gage	Max Operating Temp Deg F
Medical Gas (MG)	Varies	150
Medical Vacuum (MV)	Varies	70
Oxygen (O)	Varies	-
Sizes	½ inch and larger	
Pipe	Medical Gas and Oxygen: Copper Type K, Medical Vacuum: Copper Type L, Piping shall be specially prepared and labeled for medical service, oxygen and vacuum.	
Wall Thickness	Standard Weight	
Remarks		

<b>PIPE CODE P-9</b>		
Service	Max Operating Pressure lb/in2 gage	Max Operating Temp Deg F
Irrigation, Outside Building (I)	100	70
Lake Water (LW)	Varies	70
Sea Water (SW)	Varies	70
Well Water (WW)	Varies	70
Sizes	½-inch and larger	
Pipe	Polypropylene or CPVC or PVC if not exposed. Sea water, outside: HDPE	
Wall Thickness	Schedule 40	

<b>PIPE CODE P-10</b>		
Service	Max Operating Pressure lb/in2 gage	Max Operating Temp Deg F
Fire Protection (F)	-	-
Sizes	See remarks.	
Pipe	See remarks.	
Wall Thickness	See remarks.	
Remarks	Refer to NFPA and Environmental Health & Safety Design Guide – Sprinkler Protection & Standpipes section.	

**Valves**

- Provide valves with flanged, grooved or threaded ends. Valves may have solder ends for 2-inch and smaller copper piping. See Mechanical - Piping section.
- Provide gate valves with rising stem and union bonnet for 2-inch and smaller.

- Provide ball valves for 2-inch and smaller pipe and butterfly valves for 2½-inch and larger pipe.
- Balancing valves shall be globe type with ports and graduated scale. Balancing valve shall not be used as an isolation valve.
- Plug valves larger than 2-inch size shall be lubricated type.

#### **Strainers**

- Provide wye type strainers in 2-inch and smaller piping.
- Provide basket type strainers in piping larger than 2-inch, except for steam piping.
- Provide wye type strainers in steam piping.
- Strainer body material shall match the piping material.
- Provide strainer screens with a free area not less than three times the free area of the pipe line. Perforations should be 1/16-inch size. Provide stainless steel screens in steam strainers. Provide brass screens in all other strainers.

### **Installation, Fabrication and Construction**

#### **Pipe and Fittings**

- Do not install piping below slabs on grade, except for waste and vent piping.
- Provide a minimum of two 90 degree changes in direction at each branch connection, particularly in heating systems, with reasonable pipe lengths to allow for pipe movements.
- Provide pipe expansion loops wherever possible. If required, manufactured expansion joints or flexible connections may be used.
- Provide unions or flanged connections at equipment for maintenance and repair.
- Provide insulating nipples or flanges between copper and galvanized connections.
- Provide welding outlets where branch piping is smaller than the main. Provide welding tees for all other cases.
- Welders must be certified by the National Certified Pipe Welding Bureau.
- Patch wall/floor openings to match adjacent material after removal of pipe and ductwork.
- Do not provide flexible connections without Campus Engineering approval. Rubber flexible connectors are not acceptable.
- All piping and tubing shall be reamed and all burrs removed.

#### **Pipe Sleeves**

- Provide sleeves large enough to allow insulated piping pass through without disrupting the insulation.
- Provide Link Seal, or approved substitution, on all sleeves through exterior walls below grade.
- Provide UL Listed fire-stopping material on all sleeves through fire rated floors and walls.

### **Valves**

- Install valves with the stem vertical. When this is not possible, they may be installed rotated but never less than horizontal under any circumstance.
- Provide isolation valves at each floor.
- Install isolation valves staggered where they come out from a pipe shaft so they are completely and conveniently accessible.
- Install valves with adequate room to permit removal of the bonnet, disk, and trim without removing the valve from the line.
- Provide globe valves where throttling is required, except for balancing valves.
- Provide valve tags for each valve where the destination is not visible. Tags must state service and destination.
- Provide balancing valves at all pumps, main pipe branches, and all system coils.
- Triple Duty valves are not allowed.
- Discuss the sizing of balancing valves for small coils (less than 1 gpm) with Campus Engineering.

### **Strainers**

- Provide a ball valve and hose-end adapter for blow-down on all wye strainers, except use gate valve on steam and condensate strainers.
- Provide strainers ahead of automatic control valves, steam traps, and in main service piping to buildings. Those steam traps provided for a device having an automatic control valve do not require strainers.

### **Headers**

- Space components apart by at least two pipe diameters between flanges.
- Locate header assemblies approximately 4 feet above the floor.

END OF DESIGN GUIDE SECTION