



# Designer's Guide

By Ron George, CIPE, CPD, SmithGroup Inc., Detroit, MI

## Piping Materials

When writing piping specifications, the engineer has a host of pipe material standards and pipe material choices to choose from. The piping materials described here are commonly used for plumbing, HVAC, and other industrial piping applications. This article includes general information about piping applications and specification reference standards for various piping materials. Engineers should make sure one of these standards is referenced and specified when writing piping specifications.

### Steel pipe

The standards covering steel pipe are covered in the American Society of Testing and Materials (ASTM) A 53. Steel piping is typically used in HVAC heating and chilled water applications. It also is used for steam and condensate and when zinc coated or galvanized it can be used for domestic water distribution systems above ground.

Steel pipe may be black or galvanized (zinc coated). Steel piping for potable water must be galvanized. Black steel piping is typically painted after installation or insulated with a vapor barrier type of insulation to avoid rusting from condensation.

### Wall thickness/class

Steel pipe is produced in three weight classes:

- Standard (Schedule 40) is typically available in 10-inch and smaller.
- Extra-Strong (Schedule 80) is typically available in 8-inch and smaller.
- Double-Extra-Strong (equivalent to Schedule 160) is available but is not typically used for mechanical work.

Standard class pipe is available in 1/8-inch to 26-inch and is supplied in random lengths from 16 to 22 feet.

Standard and Extra-Strong pipes, 12 inches and larger, are available, but the schedule numbers or equivalent schedule numbers are less than Schedule 40.

### Steel pipe types

Type "F" is furnace-butt welded and is made in Grade "A" only. Type "F" Standard pipe is made only in 5-inch and smaller sizes and it is not suitable for flanging. Type "F" pipe is usually not listed in Master Specifications.

Type "E" is electric-resistance welded and is made in Grades "A" and "B". Type "E" steel pipe may be used for high-pressure steam piping. Refer to the American Society

of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code* and ASME B31.1, *Power Piping Standard*. Type "E" pipe is available with plain or threaded ends. Type "E" pipe is also available in an outside diameter (OD) of 15 inches and larger with plain ends.

Type "S" is wrought-steel seamless pipe and is made in Grades "A" and "B". Type "S" steel pipe is expensive and should only be specified if required. It is most often used

---

**Type "S" steel pipe is most often used when it is going to be bent or coiled in the manufacturing process in lieu of using fittings.**

---

when it is going to be bent or coiled in the manufacturing process in lieu of using fittings.

An alternative to specifying Nominal Pipe Size (NPS) is to specify the outside diameter (OD) and the nominal wall thickness. This alternative is common for high-temperature applications. Type "E" or Type "S", Grade "A" steel pipe is preferred for close coiling or bending and high temperature applications.

### Pipe fittings for steel piping

**Cast iron fittings** are available in threaded or flanged fittings in Classes 25, 125, 250, and 800. Classes 125 and 250 are normal for building service piping. ASME B16.1 includes dimensions, materials, and recommended bolts and gaskets. Cast-iron flanges and threaded fittings are available for Classes 125 and 250. ASME B16.4 includes materials and dimensions. Fittings are available with a galvanized finish.

**Malleable-iron fittings** are available for Classes 150 and 300. ASME B16.3 includes materials and dimensions. Fittings are available with a galvanized finish.

**Steel flanges and flanged fittings** are available in Classes 150 to 2500. See standards for relationships among classes, working pressures and temperatures. Several facings, such as raised face (most common), ring joint, and

*Continued on page 20*

# Designer's Guide

Continued from page 18

female, are available. Threaded or welding types are available including welding end, socket, slip-on, and lapped joints.

**Welded end** (butt weld) is common in building service piping. The designer should specify the end connection and class number.

**Wrought-steel fittings** with butt-welding ends are rated according to the attached pipe. ASME B16.9 includes materials, dimensions and end types including bevel end for use with a backing ring.

**Forged-steel fittings** with socket-welding or threaded ends are for normal pipe up to a nominal pipe size of 4-inch and for maximum ratings of Class 6000 for threaded and Class 9000 for socket welding. Ratings are based on a pipe schedule.

**Malleable-iron unions** are available in Classes 150, 200, 250, and 300 and in hexagonal or round stock. Joints may be malleable iron with a gasket, or ball to cone with a malleable-iron ball and a malleable-iron, brass, or polytetrafluoroethylene (often called Teflon) O-ring cone seating surface. Threaded ends may be male or female.

## Copper tube

Determine the type of copper tube suitable for an application by considering internal or external fluid pressure, installation and service conditions, and local requirements. Methods of joining or bending also affect tube-type selection.

## Metric conversions

SI (metric) copper-tube sizes are indicated differently from inch-pound tube size designations. The inch-pound designation is a nominal (standard) size. The OD of water tube and drainage tube is 1/8 inch (3.2 mm) larger than the nominal size. ACR tube uses the nominal OD. SI or metric tube sizes are close to actual conversions of the tube's nominal OD. The following types of copper piping are for building services:

- **Type "K" seamless copper tube** should meet the standard, ASTM B 88, Type "K" (ASTM B 88M, Type A) seamless copper water tube. Type "K" has the thickest

wall of the copper tubing materials. Type "K" is available in 1/4-inch to 2-inch in annealed or soft temper in coils and in 1/4-inch to 12-inch in annealed and drawn tempers (rigid) in straight lengths. Annealed tube has markings indicating the tube type. Drawn tube has green markings. Type K (Type A) annealed tube is commonly used for underground water services if conditions are severe.

- **Type "L" seamless copper tube** should meet the standard, ASTM B 88, Type "L" (ASTM B 88M, Type B) seamless copper water tube. Type "L" tubing has a medium-thick wall. Type "L" is available in 1/4-inch to 2-inch in annealed soft temper in coils and it is available in 1/4-inch to 12-inch in annealed and drawn tempers (rigid) in straight lengths. Annealed tube has markings indicating the tube type. Drawn tube has blue markings. Type L (Type B) drawn tube is normally used for most applications. Type L (Type B) annealed tube may be used for underground water services.
- **Type "M" seamless copper tube** should meet the standard, ASTM B 88, Type "M" (ASTM B 88M, Type C) seamless copper water tube. Type "M" tubing has a thin wall. This type is available in 3/8-inch to 12-inch, except for 5/8-inch in drawn temper (rigid) in straight lengths. Annealed tube has markings indicating the tube type. Drawn tube has red markings. Type "M" (Type C) is used for the same applications as Type "L" (Type B) if conditions are not severe.
- **Type "ACR" seamless copper tube** should meet the standard, ASTM B 280, Type "ACR" seamless copper tube for air-conditioning and refrigeration field service. Type "ACR" tubing has a medium-thick wall and is pre-cleaned and sealed. This type is available in 3/8-inch to 1-5/8-inch in soft-annealed temper in coiled lengths and in 3/8-inch to

4-1/8-inch in drawn temper in straight lengths. The nominal size is the tube's OD. Weights and wall thicknesses are the same as ASTM B 88, Type L (ASTM B 88M, Type B) for equivalent (but not nominal) sizes. The tube or its package has blue markings.

- **Type "DWV" copper drainage tube** should meet the standard, ASTM B 306, Type DWV. Copper drainage tube has a thinner wall than Type M (Type C) water tube. This type is available in 1-1/4-inch to 8-inch in drawn-temper straight lengths only. The OD is 1/8-inch (3.2 mm) larger than the nominal size. Tube has yellow markings. The engineer should specify Type L or M (Type B or C) water tube if tube smaller than 1-1/4-inch or larger than 8-inch pipe is required.
- **Medical gas service** tubing should meet the standard, ASTM B 819, Types "K" and "L", copper medical gas tube is the same as ASTM B 88, Types K and L. There are no SI (metric) equivalent types. The only difference between type "K" or "L" tubing is this tube has been cleaned for medical gas service. These types are available in 1/4-inch to 8-inch in drawn-temper (rigid) straight lengths only. The OD is 1/8-inch (3.2 mm) larger than the nominal size. Tube has marking similar to "OXY" or "MED" with green markings for Type "K" and blue markings for Type "L" tubing.

## Considerations for copper tube

Use Type K (Type A) annealed or soft tempered tubing for underground service and hard drawn temper for general plumbing services if corrosion conditions are severe. Use Type L (Type B) hard drawn temper for interior service and annealed soft temper for underground, general plumbing, and heating services if conditions are normal. Use Type M (Type C) for waste and vent, heating, and other services in conditions less severe than those for which Type K or L (Type A or B) is recommended. Type DWV is lighter in weight than Type M (Type C). Use

Continued on page 22

July 2001

# Designer's Guide

Continued from page 20

Type DWV for drainage and non-pressure applications. Do not use Type DWV tube underground. Heavier Type L (Type B) is suitable for underground drainage applications; however, do not embed copper tube in areas with cinder fill or ashes. Copper can corrode in these conditions.

Use Type ACR for HVAC service. Use Type K or L drawn temper medical gas tube for medical and laboratory gas service, except annealed temper tube may be used for underground vacuum tubing.

## Copper fittings

Engineers should specify copper-tube fitting types according to the following ASME Standards:

- ASME B16.18 cast-copper and ASME B16.22 wrought-copper, solder-joint pressure fittings with ASTM B 88, Types K, L, and M (ASTM B 88M, Types A, B, and C) tube and ASTM B 280, Type ACR tube. Also use these fittings for drainage piping smaller than 1-1/4 inches and larger than 8 inches.
- ASME B16.26 cast-copper, flared-joint fittings with ASTM B 88 (ASTM B 88M) and ASTM B 280 soft-annealed tubing.

---

**Using grooved joints inside buildings provides flexibility for expansion and contraction.**

---

- ASME B16.23 cast-copper and ASME B16.29 wrought-copper, solder-joint drainage fittings with ASTM B 306, Type DWV tube. Also use these fittings with tube types such as ASTM B 88, Type M (ASTM B 88M, Type C) if small-size or thicker tube wall is required. These fittings are not suitable for pressure applications.

## Ductile-iron pipe

Centrifugally cast ductile iron pressure pipe is the most commonly used for underground water mains. Use AWWA C115 pipe and fittings with cement lining and grooved or threaded flanged ends inside buildings. Use bell-and-spigot pipe and fittings for water and sewer piping. Equivalent pressure ratings are 350 psig in 12 inches and smaller, and 150 to 350 psig in larger sizes.

Types of pipe joints include mechanical, push on, restrained,

*Continued on page 24*

July 2001

Circle 012 on Reader Service Card

# Designer's Guide

*Continued from page 22*

grooved, and flanged. Use grooved joints inside buildings to provide flexibility for expansion and contraction. Flanged joints are rigid; each section of pipe must be cut, and the flanges must be assembled to exact dimensions.

Mechanical and push-on joints are suitable for underground use. Flanged and grooved joints are suitable for use aboveground and in pits. Ductile-iron pipe is formed from iron that has a higher magnesium content than conventional cast iron, which gives pipe high ductility and toughness. Although ductile iron is centrifugally cast, describe it only as ductile-iron pipe to

to PVC plastic pressure pipe. ABS plastic pipe is available in the same schedule numbers and pressure classes as PVC plastic pipe. ABS plastic pipe usually has lower tensile strength but better impact resistance than PVC of an equivalent grade. Both types may be used, and are satisfactory for, plumbing piping. The most common application for ABS pipe is for drainage.

**CPVC** pipe is for higher temperature service, about 180 F, than PVC pipe. Such applications include domestic hot-water supply and return piping and heating systems.

**PEX** is a plastic tube that may be

---

## An alternative to specifying Nominal Pipe Size (NPS) is to specify the outside diameter (OD) and the nominal wall thickness.

---

avoid confusion with centrifugally produced cast-iron pipe. Mechanical and push-on joint pipe types are available in various classes. Pipes with flanged joints using threaded flanges are available. Ductile-iron pipe may be radius-cut grooved for use with grooved-end fittings, keyed couplings, and grooved joints.

### **Plastic pipe**

Plastic pipe may be used in plumbing and HVAC piping systems. Plastic pipe has lower hydraulic friction losses compared to cast-iron and steel pipe and copper tube. This quality sometimes allows smaller pipe sizes. One thing to keep in mind is plastic piping will require more hangers or in some cases continuous support. Plastic drainage piping is also noisy compared to cast iron. In certain residential and process applications, plastic piping can be a very economical choice.

**ABS** pressure pipe is made from various grades of rubber-base resin. Type I is normal-impact type; Type II is high-impact type. Its uses are similar

used for hot and cold water distribution systems at pressures to 100 psig and 180 F, replacing the polybutylene systems previously used. PEX gets its name from the cross linking of the polyethylene plastic. Polyethylene is the same material that plastic beer cups are made of. If you try to tear the cup it tears in one direction from top to bottom, but not side to side. With cross-linked polyethylene the manufacturers build the material up in layers that are cross-linked or oriented in different directions to give the piping its strength. With PEX systems, individual tubes are typically run from a central manifold to each supply to each fixture. The ASTM standard lists sizes from 1/4-inch to 2-inch; however, manufacturers' data limit the available sizes to 1/4-inch to 1-inch. Joints are typically of the compression type.

**PEX-AL-PEX** composite pipe has a layer of aluminum tubing between two layers of PEX. It may be used for hot- and cold-water distribution systems at sustained pressures to 395 psig and

*Continued on page 26*

## Designer's Guide

Continued from page 24

180 F, replacing the polybutylene or PEX systems previously used. Individual tubes are run from a central manifold to each supply to each fixture. This pipe is available in 1/4-inch to 1-inch. Joints are typically of the compression type.

**PE** (polyethylene) pressure pipe may be used at temperatures below 120 F and is available in black with ultraviolet inhibitors for installations exposed to light. PE pipe supports combustion. This pipe is more flexible than ABS or PVC plastic pipe. It is available in coils, in pressure series up to 120 psig calculated at 70 F. Class 160 pipe is available for residential water-service connections and is used for underground, outside, natural gas systems. Pipe for water services may be joined by insert fittings. Other joining methods use heat-fusion joints.

**PVC** pressure pipe may be used for underground and aboveground water piping. Schedule 40 is joined with solvent cement. Schedule 80 is available in pressure Classes 100, 125, 160, and

200 and is joined with solvent cement or by threaded joints. Use Type I, normally impact-resistant pipe, and Type II, high-impact-resistant pipe, for tough handling or service conditions. The upper temperature limit is 140 F. Protect PVC pressure pipe against freezing. PVC pipe is common for sewer and drainage, waste, and vent applications.

**Fiberglass** pipe may be used in plumbing and HVAC piping systems. Several designations have been used for fiberglass pipe. AWWA recommends that the pipe be called *fiberglass*. AWWA and ASTM use the designations "RTRP" for pipe, "RTRF" for filament piping, and "RTMP" and "RTMF" for mortar piping. Fiberglass pipe has lower hydraulic friction losses compared to many pipe materials. This quality sometimes allows smaller pipe sizes.

**Cast-Iron Soil Pipe** hub-and-spigot pipe and fittings are available in ASTM A 74, Extra Heavy and Service classes. Cast-iron hubless pipe and fit-

tings are specified in ASTM A 888 and CISPI 301, hubless class, and are used in plumbing systems. Cast iron piping is often specified for sanitary waste and vent piping and storm drainage piping. The Cast Iron Soil Pipe Institute offers CISPI Standards for free along with its "Cast Iron Soil Pipe Specifiers Guide." This manual can be obtained by calling 615/892-0137.

**High-silicon iron pipe** and fittings are available in ASTM A 861, bell and plain-end and mechanical-joint design. High silicon iron pipe is resistant to acid and is sometimes specified as an acid or chemical waste pipe material.

**Borosilicate-glass pipe** and fittings are available in sizes meeting the standards ASTM C 599 and ASTM C 1053, mechanical-joint pattern. Glass piping is typically specified as an acid waste or chemical waste piping material.

**Fabricated, insulated pipe** — manufactured, pre-insulated piping systems are available. They have an inner carrier pipe that is suitable for the fluid to be transported in, insulation (usually), and an outer protective jacket. Manufacturers have developed a wide range of carrier pipe materials with an assortment of insulation and jacket types. Pre-insulated piping is commonly used for hydronic distribution and steam distribution piping systems.

**Dual-containment pipe** — manufactured, dual-containment piping systems are available in both pressure pipe and drainage pattern fittings. They have an inner carrier pipe that is suitable for the fluid to be transported in, an open annular space, and an outer protective jacket. A leak-detection system may be installed in the annular space, or the pipe could be sloped to leak detection monitoring wells. Dual containment piping systems are available in a wide range of material choices and are commonly used on industrial process waste systems, fuel-oil distribution and chemical or acid waste piping systems.

**Fire suppression piping** — piping for fire-suppression systems can be covered in individual, division 13 specification sections or in the division 15 piping specifications with a reference in division 13 fire protection specifications. □