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PIPING MATERIALS AND JOINING METHODS FOR PLUMBING SYSTEMS

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It seems there are practically as many piping materials as there are fluids to convey through them. Equally as numerous are the methods of joining lengths of pipe. The sheer number of choices presents the engineer with an important decision to make at the start of each project: Which piping material and joining method is best for this particular application? Many times the choice is obvious as circumstances such as plumbing code requirements or specialized application combine to limit the choices to one piping system. In most cases, however, the engineer must choose between several equally well suited pipe materials.

For example, consider choosing a material for piping above ground sanitary waste in Chicago. The Chicago Plumbing Code allows several choices of piping, including cast iron hub and spigot with lead and oakum joints, galvanized steel with threaded couplings, Type K copper with soldered DWV fittings, vitrified clay, ductile iron, and glass pipe. More expensive materials, such as glass, are normally used only where superior corrosion resistance is necessary and can be eliminated. Materials intended primarily for underground use can also be eliminated. The remaining choices are further limited by availability of pipe and/or fittings in certain sizes and differences in cost for various materials and installation procedures.

An obvious pattern appears in this process of deciding among materials. The first step is defining the application—what will be conveyed through the pipe, at what pressure and temperature, and in what location. Secondly, the applicable building codes must be consulted to determine what is or is not acceptable. Finally, the cost considerations of the piping material and installation must be addressed.

Choosing pipe materials and joining methods for plumbing systems, although not exceedingly difficult, is becoming more and more involved. New materials, joining methods, and changes in plumbing codes combine to make the process worthy of periodic review.

An important aspect of deciding which material to use is the knowledge of what type of piping is available. Over the years, there have been many different materials used as piping. The Romans used lead pipe and stone aqueducts. Early American colonists used logs cut in half, notched, and joined back. Hollowed bamboo is still used where it is available. Though most of these materials and others used over the ages are still available in some form, the majority of pipe used today falls into one of four basic categories: iron and steel, nonferrous metals (cooper, brass, etc.), plastic, and hardened stone materials (cement, clay, etc.).

Each of these piping materials has its own subcategories, specialized uses, and joining methods and standards. These standards are promulgated by a number of different agencies, some with overlapping jurisdictions, such as American Waterworks Association (AWWA), American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), and Cast Iron Soil Pipe Institute (CISPI).

The following is a fairly complete list of available piping materials and joining methods for plumbing piping, along with some applicable standards.

Iron and steel

With different types commonly used for both drainage and domestic water supply, iron and steel piping is the most prevalent in commercial building plumbing systems.

■ *Cast iron*—Cast iron piping is used for sanitary waste, vent, and storm drainage. It is available in extra heavy weight and service weight (ASTM A74). Extra heavy weight is used primarily for underground applications, although it is no longer required by many building codes. Service weight (originating during World War II when pipes were made deliberately thinner to conserve iron) is

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accepted for use both above and below ground. Fittings are generally of the DWV (drain, waste, and vent) pattern with long sweeping elbows. Both pipes and fittings are available in sizes ranging from 1.5 to 15 in. diameters. Available joining methods include hub and spigot with either lead and oakum caulked joints or neoprene push-on compression gaskets (ASTM A74) and hubless with stainless steel multi-band couplings and neoprene gaskets (CISPI 301).

■*Ductile iron*—Ductile iron piping is used primarily for domestic water service, both inside and outside buildings, including most city water systems because of its high strength and availability in varying pressure ranges from 125 to 350 psi. It is also available with various coatings, including tarred, cement lined (AWWA C104), and PVC coated (ANSI A21.5). Both pipe and fittings are available in sizes ranging from 3 to 54 in. Available joining methods include flanged and bolted, mechanical couplings (shoulder type), roll and cut groove with mechanical couplings, and bell end with push-on fittings (ASTM A377, AWWA C151, ANSI A21.10, ANSI A21.11)

■*Carbon steel*—Carbon steel piping is available as either black (uncoated) or galvanized. In plumbing systems, galvanized steel is commonly used for interior domestic water distribution. Black iron is used for fire protection and natural gas (ASTM A-53). Both types are available in various wall thicknesses, ranging from Schedule 5 (lightest) to Schedule 160 (heaviest) with corresponding pressure ratings. Both pipe and fittings are available in sizes ranging from 1/8 to 24 in. Joining methods include threading (screwed couplings are not acceptable with Schedule 5 and questionable with Schedule 10), welded, cut, and roll grooved with mechanical couplings that are flanged and compression fitted (used with Schedule 5 pipe and fittings). (ASTM A106, ASTM A135, ANSI B36.1)

■*Stainless steel*—Stainless steel piping, available in various alloys, is used for process piping, high-purity gas, corrosive waste, or other specialized systems. It exhibits a higher strength to weight ratio than carbon steel, so it is sometimes used for high pressure applications. Both pipe and fittings are available in 1/8 through 48 in. Joining methods include threaded, flanged, or welded.

■*Iron alloy*—High silicon iron alloy piping is used for corrosive waste drainage when cast iron is unsuitable. Several different alloys with varying resistivities are available. Pipe and fittings are available in sizes ranging from 2 to 10 in. Joining methods are similar to those for cast iron piping.

Nonferrous metals

Nonferrous metals include copper, brass, aluminum, lead, and other specialized piping materials. Of these, copper is the most prevalent.

■*Copper tubing*—Copper tubing of different wall thicknesses is used for both buried and interior domestic water piping (ASTM B75, B88, B521, B447), medical and laboratory gas piping, and sanitary drain and vent piping. The wall thicknesses available are classified as Types K, L, M, and DWV, with Type K having the thickest wall and Type DWV the thinnest. Most plumbing codes identify the applications for which each type of piping can be used. Types K and L are used for above- or below-ground water and gas, Type M is used for above-ground water, and Type DWV is used for drainage. Types K and L, when cleaned for oxygen service, are used for medical gases. Copper tubing for all four types is manufactured in sizes ranging from 1/4 to 12 in., but sizes over 6 in. are not readily available. Fittings can be either flared end copper or wrought or cast brass. Joints can be made with a variety of different solder alloys. It is important to remember that only approved lead free solders are allowed for the joining of potable water supply lines by brazing or with rolled grooved couplings. Local codes should be consulted to determine which alloy is acceptable for each particular service.

■*Brass*—Brass piping is used for high-pressure water distribution. Its high strength makes it suitable for use in high-rise buildings since pressure ratings are available up to 3000 psi. Pipe is available in sizes ranging from 1/8 to 12 in. Joints are made with wrought copper or brass fittings and either soldered, flanged, threaded, or brazed couplings. (ASTM B43, ASME SB43)

Brasses have historically contained various amounts of lead. Because of a federal EPA mandated requirement to eliminate the hazard of lead in drinking water, manufacturers are working hard to reduce the amount of lead or eliminate it entirely in products that convey potable water.

■*Lead piping*—Lead pipe has long been used as water supply, corrosive waste, and process piping. Although currently no longer used for water supply (because lead is a human health hazard), it is still a viable alternative for the other applications. Pipe is available in varying wall thickness and sizes ranging from 1/4 to 12 in. Joints are either lapped, flanged, or welded. (ASTM B29)

■*Aluminum*—Aluminum tubing is used for specialty services such as cryogenic liquids and gases. Wall thicknesses available are similar to those of copper tubing. Sizes are available ranging from 1/8 to 12 in. Joints are made by either brazing or welding.

Plastic

Plastic piping encompasses a wide variety of materials and is used for every imaginable service. Common uses include sanitary and corrosive waste drainage, water distribution, gas distribution, fire protection, and process piping.

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The different types of plastic piping are available in a variety of thicknesses and sizes. Acceptability of certain types of plastic pipe for various applications is constantly changing, and local codes should be consulted for locations and applications where plastics can be used and for flame resistivity requirements.

■*ABS (acrylonitrile-butadiene-styrene)*—This type of plastic is commonly used for drainage systems. Sizes available range from 1/4 to 24 in. in Schedules 40 and 80. Joints are made by solvent welding or threading (Schedule 80). (ASTM D2661, F628)

■*CPVC (chlorinated polyvinyl chloride)*—Most often used for domestic water (including hot water) distribution, CPVC is available in sizes ranging from 1/4 to 12 in. in Schedules 40 and 80. Joints are made by solvent welding, threading (Schedule 80), flanges, and mechanical couplings. (ASTM D2846, ASTM F441, ASTM F442)

■*Glass fiber*—Glass fiber piping is made in a variety of thicknesses and most sizes are available. Standard sizes range from 1/2 through 144 in., with custom-made larger sizes also available. Used for corrosive wastes, process piping, and secondary containment systems, the benefit offered is field adaptability, as field fabrication of whole or half pipes is readily achievable. Joints are made by field constructing, threading, flanging, or mechanical couplings.

■*PB (polybutylene)*—This type of plastic is used for hot and cold water distribution and fire protection and is available in small sizes from 1/4 to 2 in. Joints are made with heat fusion or hose clamps. (ASTM D2662, D2666, D3309)

■*PE (polyethylene)*—This type is widely used for natural gas distribution (underground) and domestic water supply. Sizes available range from 1/2 to 30 in. Joints are made by heat fusion or with hose clamps. (ASTM D2737, F405)

■*PP (polypropylene)*—Polypropylene is used for process piping, high-purity water, and corrosive waste drainage and is available in Schedules 40 and 80 in sizes ranging from 1/2 to 8 in. (some fittings are not available in 8 in.). Joints are solvent welded, heat fusion (socket or butt), mechanical couplings, threaded (Schedule 80), or flanged. (ASTM D2146)

■*PVC (polyvinyl chloride)*—PVC is used for sanitary and corrosive drainage (ASTM D2665, D2949), high-purity water, water distribution (ASTM D1785, D2241), and process piping and is available in Schedules 40 and 80 in sizes ranging from 1/8 to 12 in. Joints are made by solvent welding, threading (Schedule 80), or mechanical couplings.

■*PVDF (polyvinylidene fluoride)*—Often called by its trade name of Kynar, PVDF is used for process piping and high-purity water and is available in Schedule 80 in sizes ranging from 1/2 to 8 in. (some fittings are unavailable in 8 in.). Joints are made by heat fusion (socket or butt) and mechanical couplings, either threaded or flanged.

Stone-based materials

Stone-based materials are generally centrifugally spun in molds, then cured (as with cement) or fired at a high temperature (vitrified clay products). Most often used for underground drainage, this type of piping is most economical in larger sizes.

■*Asbestos-cement*—This material is used primarily for sanitary and storm drainage, pumped waste lines, and water distribution when it is expoy-lined. It is available in sizes 3 to 42 in. with pressure ratings up to 200 psi. Joints are made through bell-and spigot-ends with rubber gaskets for push-on applications. (ASTM C428)

■*Clay tile (vitrified clay)*—This material is used for corrosive waste, sanitary sewer, and subsoil drainage piping with pre-formed openings and is available in standard or extra heavy grade, sizes from 4 to 41 in. Joints are made with bell-and-spigot ends with or without push-on gaskets. (ASTM C4, C700)

■*Concrete*—Concrete is used for storm and sanitary drainage and subsoil drainage pipe in porous form and is available in nonreinforced (4 to 36 in.) and reinforced (12 to 144 in.). Joints are made with bell-and-spigot ends plastered over with cement. (ASTM C14, C76)

■*Glass*—Borosilicate glass piping is used both above and below ground for corrosive waste drainage and high-purity water and is available in sizes 1/2 to 6 in. Joints are made using stainless steel couplings with gaskets made of a variety of materials, depending upon application. (ASTM C599-77)

With all of these available choices, many adequate for use in various piping applications, each particular system requires consideration. As previously mentioned, there are definite steps to the process.

Making the choice

The first step is to define the application. This involves identifying all the aspects of the material to be conveyed. In the case of domestic water, the pressures and temperatures involved, as well as the chemical content or hardness of the water, need to be defined. For drainage systems, the types of wastes (sanitary, storm, and corrosive) need to be defined. The quality of water required in high purity water systems must be defined. Location of pipe routing must also be considered. Will the pipe be below or above ground, in a plenum ceiling space, in a heated or unheated space, or close to a potential high heat source?

After one has defined the exact service requirements and location of installation for the piping, searching the applicable code for materials allowed in this application becomes relatively simple. More often than not, a plumbing code allows a large number of piping materials and joints for any particular application.

To limit the field of available choices further, economic considerations can be applied. This includes not only the obvious cost of materials but the cost of installation as well. In many cases, small diameter drainage piping and copper DWV piping, though more expensive than threaded galvanized steel on a material basis, are less expensive overall because installation is quicker. Large pipe diameters of hubless cast iron drainage piping, easier and quicker to install than hub and spigot cast iron, require additional pipe hangers and restraints and may prove more costly to install in the long run.

Other considerations that do not clearly fall under any of the above categories are also important. The life span of a particular installation must be considered. Ease of alteration for future renovations is important in some cases. Noise transmission through piping in occupied spaces is sometimes an issue. Choosing between PVC, which is noisier than cast iron drainage piping, is an example. In addition, some sizes of pipe and fittings are not available in all materials, or there may be a problem involving lead time in deliveries for some materials.

Conclusion

All in all, choosing a pipe material or joining method, although not exceedingly difficult, is becoming more and more involved. New materials, new joining methods, and changes in plumbing codes combine to make the process worthy of periodic review. The engineer must continually evaluate new methods and materials against the old because in many cases the final decision is not based on the previously mentioned criteria but rather on the preference of the individual engineer. Ω

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