Chapter 3:
General Regulations

General Comments

The content of Chapter 3 is often referred to as "miscellaneous," rather than general regulations. Chapter 3 received that label because it is the only chapter in the code whose requirements do not interrelate. If a requirement cannot be located in another chapter, it should be located in this chapter.

Some nonplumbing regulations merely reference other codes that have the specific requirements. The requirements provide a cross reference to the appropriate document, recognizing that it affects the plumbing system but the details are not specifically contained in the code (Sections 307, 309, 310 and 313 reference other International Codes®).

The jurisdictional requirements specify that the water and sewer must connect to the public system when a public system is provided (Sections 602.1 and 701.2 are more specific on this issue).

Nonplumbing requirements include surface requirements for walls and floors in a toilet room, light and ventilation, floodproofing and rodentproofing.

Purpose

Chapter 3 contains safety requirements for the installation of plumbing and nonplumbing requirements for toilet facilities, including requirements for the identification of pipe, pipe fittings, traps, fixtures, materials and devices used in plumbing systems.

The safety requirements provide protection for the building's structural members, stress and strain of pipe and sleeving. The building's structural stability is protected by the regulations for cutting and notching of structural members. Additional protection for the building occupants includes requirements to maintain the plumbing in a safe and sanitary condition, as well as privacy for those occupants.

SECTION 301
GENERAL

301.1 Scope. The provisions of this chapter shall govern the general regulations regarding the installation of plumbing not specific to other chapters.

❖ The requirements included in Chapter 3 are not interrelated, as is typical with other chapters. Many regulations are not specific plumbing requirements but relate to the overall plumbing system.

301.2 System installation. Plumbing shall be installed with due regard to preservation of the strength of structural members and prevention of damage to walls and other surfaces through fixture usage.

❖ The installation of plumbing systems in a building should not result in the strength of the building's members being compromised. There is often a need for piping to be routed through structural and nonstructural members of the building. The *International Building Code*® (IBC®) provides limitations for alteration of some of the more common building members such as studs, joists and rafters. Appendix C is a reprint of those limitations. Section 307 of the code provides additional direction.

Clearances around fixtures are covered in Section 405 and provide for the necessary space to allow the fixtures to be used without causing damage to walls or other surfaces such as doors. Note that the requirements for accessibility in Section 404 could require more clearance around fixtures. Chapter 12 of the IBC provides information about interior building surfaces in toilet and bathing facilities.

301.3 Connections to drainage system. Plumbing fixtures, drains, appurtenances and appliances used to receive or discharge liquid waste or sewage shall be directly connected to the sanitary drainage system of the building or premises, in accordance with the requirements of this code. This section shall not be construed to prevent indirect waste systems required by Chapter 8.

Exception: Bathtubs, showers, lavatories, clothes washers and laundry trays shall not be required to discharge to the sanitary drainage system where such fixtures discharge to an *approved* system in accordance with Chapters 13 and 14.

❖ All wastewater captured or generated within a building is required to be directed into the sanitary drainage system. In most cases, the connection to the drainage system is a direct connection, meaning that each drain pipe, (typically from a fixture's trap) is routed in a continuous manner to its connecting point to a branch of the sanitary drainage system. However, there are some situations where it is not desirable to have a direct connection. For example, a direct connection of the drainage pipe of a commercial kitchen food preparation sink is not desirable because a wastewater backup could contaminate the contents of the sink, perhaps without being noticed by kitchen staff. In these special cases, the drainage pipe is required to discharge through an air break or an air gap into a waste receptor (usually a floor sink.) The outlet of the waste

receptor is directly connected to the sanitary drainage system. Chapter 8 covers which fixtures and appliance drains are required to be indirect connected.

The exception to this section recognizes that certain wastewater flows (graywater) can be a source of water that can be treated and reused for the purposes of water-closet flushing, urinal flushing or subsurface irrigation. These wastewater flows must be collected by a drainage system that is separate from other portions of the sanitary drainage system carrying wastewater that cannot be ultilized in a graywater system.

301.4 Connections to water supply. Every plumbing fixture, device or appliance requiring or using water for its proper operation shall be directly or indirectly connected to the water supply system in accordance with the provisions of this code.

❖ Fixtures, devices and appliances that require potable water or nonpotable water must be connected, directly or indirectly, to the water supply. In other words, a sink (other than a floor sink) cannot be installed without a faucet installed on the sink.

Indirect connections include faucets or fixture fittings discharging into fixtures such as tubs and lavatories. Direct connections occur at water closets and urinals. Water closets and urinals can be supplied with treated graywater through a direct connection to the fixture if the system meets the requirements of Chapter 13.

301.5 Pipe, tube and fitting sizes. Unless otherwise indicated, the pipe, tube and fitting sizes specified in this code are expressed in nominal or standard sizes as designated in the referenced material standards.

❖ Pipe, tube and fitting sizes called out in the code are nominal or standard "inch pound" (I-P) system sizes indicated in the referenced standard for a particular material type of pipe, tube or fitting. In many cases, the indicated size is not an actual measurement of the item. Examples are: 1) $^1/_2$ inch Type L copper water tubing measuring $^5/_8$ inch outside diameter and approximately 0.545 inch inside diameter and 2) $1^1/_2$ inch Schedule 40 PVC pipe measuring 1.9 inches outside diameter and approximately 1.61 inches inside diameter. Although differences in pipe or tube materials result in slightly different actual dimensions of the products, the code's size requirements are based on nominal or standard sizes so that the choice of pipe or tube material is independent.

The code could have a requirement that is specific to a pipe dimension such as "A pipe that is not less than 3 inches inside diameter." In this case, a 3-inch Schedule 80 PVC pipe would not be compliant because the approximate inside diameter is only 2.9 inches. Throughout code language, "metric" dimensions [International System of Units (SI)] for pipe sizes are provided in parenthesis or brackets after the I-P unit dimension, for example, "$^3/_4$ inch (19.1 mm)". The indicated SI dimensions are "soft conversions" of the I-P dimension, that is, the SI dimension is derived from a simple mathematical conversion from inches to millimeters. There is no attempt to identify the nominal or standard metric sizes for pipe or tube. For example, in some tube materials, 20 mm is the standard size, not 19.1 mm.

For I-P pipe or tube sizes in code tables, an SI conversion formula is provided at the bottom of the table, above any notes.

301.6 Prohibited locations. Plumbing systems shall not be located in an elevator shaft or in an elevator equipment room.

Exception: Floor drains, sumps and sump pumps shall be permitted at the base of the shaft, provided that they are indirectly connected to the plumbing system and comply with Section 1003.4.

❖ Plumbing systems are prohibited in elevator shafts and elevator equipment rooms because of inaccessibility for repairs and the potential for water damage that could be caused to the elevator equipment if a leak developed in the plumbing piping or components. The exception allows for floor drains, sumps and sump pumps to be located at the bottom of an elevator shaft (hoistway) because most elevator codes (standards referenced by the IBC) require a means to drain water from the bottom of the shaft. An indirect connection is required to prevent waste from a plumbing system from backing up into the elevator shaft. Note that a backwater valve is not intended to be used as a substitute for the indirect connection.

The designer has to make an informed decision of whether to put the discharge from the floor drain, sump or sump pump into the sanitary system, storm sewer system or perhaps, to a grade surface. Two reasons for water to be in the base of an elevator shaft are: the base of the elevator shaft is below grade where ground water (from rain events or a seasonally high water table) might enter through cracks and seams in the walls and floors of the shaft, and water from an activated fire sprinkler system could enter through elevator doors. If the water is considered to be storm water, Section 1101.3 would prohibit its discharge to the sanitary drainage system. If the water is considered to be no different than what would enter a floor drain, then Section 301.3 would require its discharge to the sanitary drainage system. Other considerations could be whether local storm water regulators or wastewater plant operators have authority to specify where such water should be discharged. In some localities, sumps (with sump pumps) that collect the water from subsoil foundation drainage systems are required to discharge to a grade surface on the building's property to lessen the impact of storm water flow during peak rainfall events.

The exception references Section 1003.4 to alert the code user that if the elevator is a hydraulic type, an oil separator is required to be installed before the discharge of the floor drain, sump or sump pump enters a plumbing system or other point of discharge such as exterior grade locations.

301.7 Conflicts. In instances where conflicts occur between this code and the manufacturer's installation instructions, the more restrictive provisions shall apply.

❖ A conflict refers to instances where the code and manufacturer's instructions differ. The code official must evaluate each circumstance of perceived conflict and identify the requirements that provide the greatest level of protection for life and property.

SECTION 302
EXCLUSION OF MATERIALS DETRIMENTAL TO THE SEWER SYSTEM

302.1 Detrimental or dangerous materials. Ashes, cinders or rags; flammable, poisonous or explosive liquids or gases; oil, grease or any other insoluble material capable of obstructing, damaging or overloading the building drainage or *sewer* system, or capable of interfering with the normal operation of the sewage treatment processes, shall not be deposited, by any means, into such systems.

❖ This section prohibits the disposal of detrimental or dangerous materials into the sewer system. Such materials can cause the pipes to clog or accelerate the clogging of pipes, which prevents the proper disposal of sewage waste. Section 1003 contains design and installation details for the use of interceptors and separators to remove oil, grease, sand and other detrimental substances.

Discharge of materials that are flammable or combustible into the public sewer system is prohibited because an accumulation of these types of materials poses a fire and explosion hazard. Insoluble chemicals that are not processed before disposal could react with other discharged chemicals to cause damage to the piping and components of the drainage, sewer and waste treatment systems. Section 803.1 provides details for using approved dilution or neutralizing devices to process harmful chemicals prior to disposal.

302.2 Industrial wastes. Waste products from manufacturing or industrial operations shall not be introduced into the public *sewer* until it has been determined by the code official or other authority having jurisdiction that the introduction thereof will not damage the public *sewer* system or interfere with the functioning of the sewage treatment plant.

❖ Harmful or hazardous industrial waste must be treated before it is discharged to the sewer. This can require the complete removal or neutralization of certain chemicals or substances.

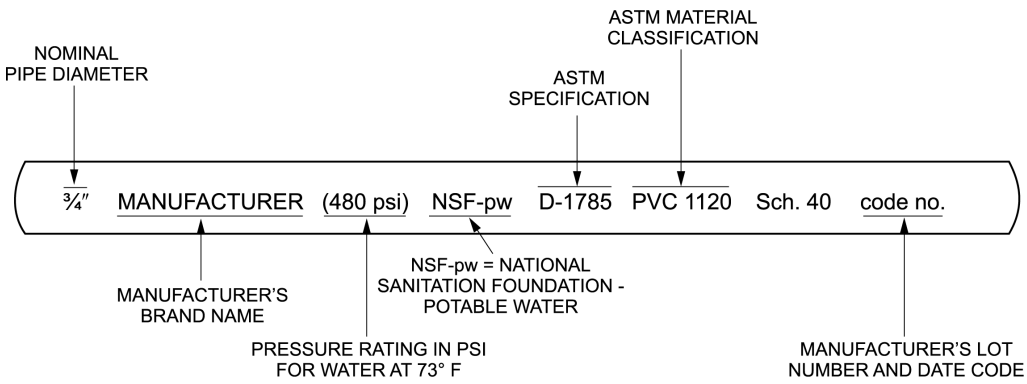
SECTION 303
MATERIALS

303.1 Identification. Each length of pipe and each pipe fitting, trap, fixture, material and device utilized in a plumbing system shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.

❖ For general accountability and rudimentary traceability within the plumbing industry, pipe, fittings, traps, fixtures, material and devices must bear the name or unique mark of its manufacturer. Should problems with the product develop at installation or at a later point time, the manufacturer can be contacted for assistance. The manufacturer has the option of determining their unique mark if their full name is not or cannot be embossed or printed on the item. Where the code requires an item to be in compliance with a reference standard, the manufacturer must comply with the requirements in the standard for marking of the product [see Commentary Figures 303.1(1) and 303.1(2)]. The requirement in Section 303.4 for third-party certification of items that are to comply with a reference standard ensures that the markings required by the standard will be present.

Several questions are commonly asked:

1. What if the installed length of pipe, cut from a longer length, is of a length that doesn't show all of the required information? The code requirement for "each length" is assumed to



For SI: 1 inch = 25.4 mm, 1 pound per square inch = 6.895 kPa, °C = [(°F) - 32]/1.8.

Commentary Figure 303.1(1)
SAMPLE MARKING OF PVC PRESSURE PIPE

mean the standard length(s) that the manufacturer offers the pipe for sale. For example, 10- or 20-foot lengths of drainage pipe. Once the pipe arrives at the project site, it will be cut to length as necessary for installation so all of the required markings may not necessarily show on shorter field-cut lengths. The intent of this section is not for all of the required markings to be indicated on every field-cut length of pipe. On most projects, longer installed lengths of pipe will show all of the markings, and generally it is assumed that the shorter lengths were cut from the same manufacturer-provided lengths of pipe. Because the code does not require that the installed piping be from the same manufacturer or be from the same production "lot," piping could have different appearances throughout a project. Also, as shorter "cut offs" from longer lengths are commonly used up for needed short lengths, there could be situations where there is a significant visible difference in appearance from adjacent longer lengths of piping. From an inspection viewpoint, how can it be determined that the shorter pipe lengths (without markings and perhaps of a different appearance) are of compliant material? The code does not address this matter.

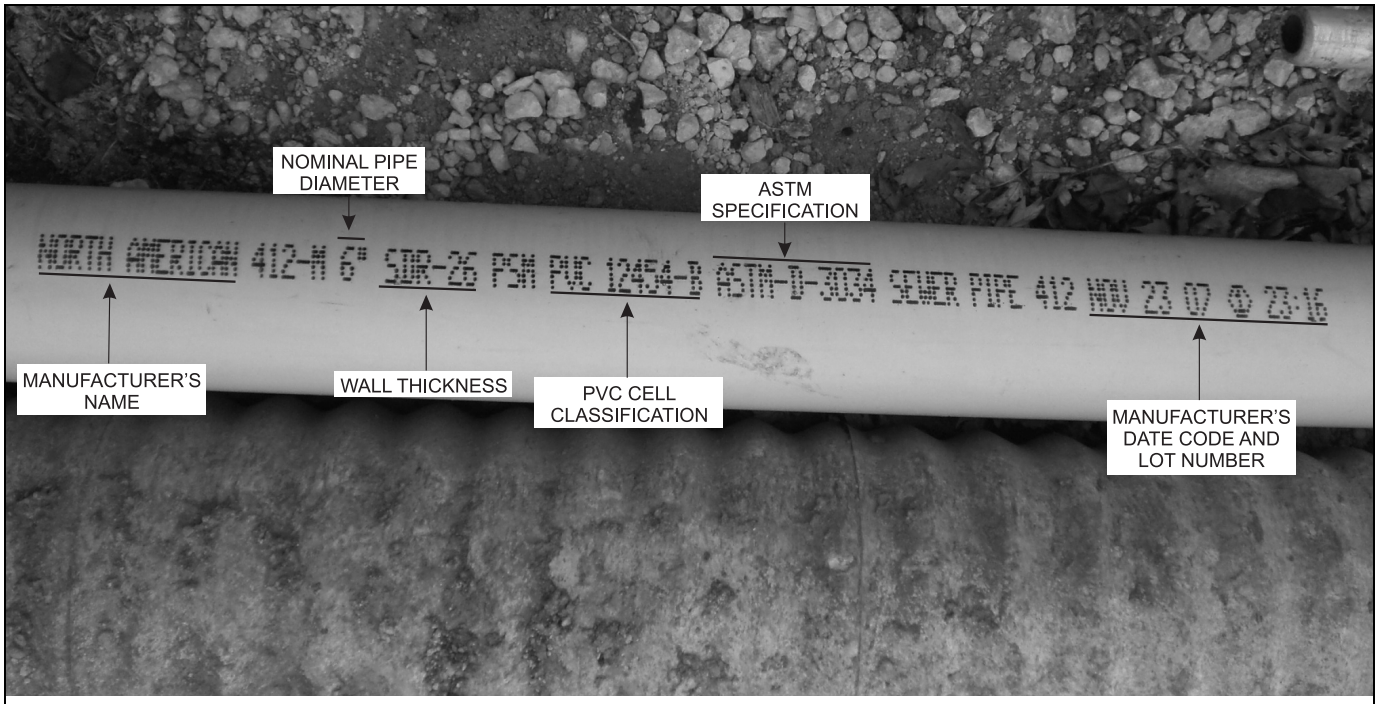
2. What if the manufactured item is too small for the manufacturer to apply all of the required information? Typically, this question arises for smaller pipe fittings and manufactured pipe nipples (see Section 605). The standards for those products allow for the packaging to have the necessary information. Although the code official can't be 100 percent certain that the packaging (if made available on request) is actually for the installed product, the code official has to use his or her own judgement about whether the appearance of the installed product seems to be similar to one that comes from a package that has the required markings.

303.2 Installation of materials. Materials used shall be installed in strict accordance with the standards under which the materials are accepted and *approved*. In the absence of such installation procedures, the manufacturer's instructions shall be followed. Where the requirements of referenced standards or manufacturer's installation instructions do not conform to minimum provisions of this code, the provisions of this code shall apply.

❖ Plumbing components and materials are to be installed in accordance with the requirements of the applicable standard indicated in the code. Where a standard is not provided, the manufacturer's instructions must be followed. For example, because there are very few standards available that regulate the installation of valves, the manufacturer's instructions must be used to install these components.

303.3 Plastic pipe, fittings and components. Plastic pipe, fittings and components shall be third-party certified as conforming to NSF 14.

❖ Plastic piping, fittings and plastic pipe-related components, including solvent cements, primers, tapes, lubricants and seals used in plumbing systems, must be



Commentary Figure 303.1(2)
MARKING OF PVC GRAVITY SEWER PIPE

tested and certified as conforming to NSF 14. This includes all water service, water distribution, drainage piping and fittings and plastic piping system components, including but not limited to pipes, fittings, valves, joining materials, gaskets and appurtenances. This section does not apply to components that only include plastic parts such as brass valves with a plastic stem, or to fixture fittings such as fixture stop valves. NSF 14 requires that plastic piping systems, fittings and related components intended for use in the potable water supply system must comply with NSF 61.

303.4 Third-party certification. Plumbing products and materials required by the code to be in compliance with a referenced standard shall be listed by a *third-party certification agency* as complying with the referenced standards. Products and materials shall be identified in accordance with Section 303.1.

❖ The term "third-party certification agency" refers to an independent organization having no financial or other interest in the outcome of tests or inspections.

The code requirements for testing and certification have frequently confused code officials and manufacturers over the years. Securing and submitting the necessary documentation for certain products and materials is sometimes a challenge for contractors and engineers. The code official is also burdened with trying to keep up with the myriad of products he or she sees in the field and the documentation that has (or has not) been submitted. To simplify inspections and approvals, the code requires the products and materials required to be in compliance with standards in the code, be "examined" by a third-party certification agency and "listed" by that agency. The definitions for "Third-party certification agency" and "Third-party certified" in Chapter 2 provide additional insight.

The code does not have a definition for "listed." Other I-Codes such as the IBC, do have a definition for "listed." Listed means that a product or material is included on a list maintained by the third-party certification agency. Such lists are freely available to the public, usually on an internet website. A third-party certification agency will only place the product or material designations such as a model number, part number, material type, on their list after they have determined that the item complies with the standards applicable to the item. The product and material manufacturers pay the third-party certification agency for this service.

In practice, the code official who is interested in determining that a product or material complies with a standard need only request of the designer or contractor, the location of the listing (or a print-out of the listing) for the item. For large projects, this process can become laborious, slowing the construction process. Most, if not all, third-party certification agencies also offer a "labeling" service to manufacturers. Such labeling of a product or material is not required by this section. However, many manufacturers do purchase this service from the third-party certification agency along with the listing service in order to make it easier for the code official to identify that the product does indeed meet all applicable standards. The label is a symbol owned by the third-party certification agency that authorizes use of that symbol by the manufacturer. The manufacturer could apply (print) the symbol to an item's specification sheet, product package, or to the item itself. In many situations, the symbol is used in all three locations; however, in other situations, the symbol might not be applied directly on an item because of the size of the item (too small) or the type of finish (such as the decorative finish on a faucet). The symbol, wherever it is located, is an easily recognizable, fast method for the code official to determine the compliance of the product or material to the standard.

303.5 Cast-iron soil pipe, fittings and components. Cast-iron soil pipes and fittings, and the couplings used to join these products together, shall be third-party listed and labeled. Third-party certifiers or inspectors shall comply with the minimum inspection requirements of Annex A or Annex A1 of the ASTM and CISPI product standards indicated in the code for such products.

❖ Section 303.4 already requires "listing," by a third-party certification agency, of plumbing products and materials required to be in accordance with code-referenced standards. This section adds the requirement for "labeling" for cast iron soil pipes and fittings, and the couplings for those products. See the Commentary for Section 303.4 for further insight.

Because not all third-party certification agencies or inspectors are familiar with the essential items, which must be inspected at the manufacturing location of these products, the annexes of the ASTM and CISPI standards are invoked to indicate the minimum requirements that are necessary for listing and labeling of these products.

SECTION 304
RODENTPROOFING

304.1 General. Plumbing systems shall be designed and installed in accordance with Sections 304.2 through 304.4 to prevent rodents from entering structures.

❖ Rodents are known to be carriers of diseases and present serious health risks to humans. To prevent the spread of disease, Sections 304.2 through 304.4 require plumbing systems to be installed in a manner that will reduce the potential for rodent entry into structures.

304.2 Strainer plates. Strainer plates on drain inlets shall be designed and installed so that all openings are not greater than $^1/_2$ inch (12.7 mm) in least dimension.

❖ Rodents often travel and live within sanitary sewer systems. The limitation for opening size in strainer plates for floor and shower drains as well as receptor strainers provides two forms of protection. If rodents are in the sewer system, strainer plates prevent them from entering the building through the floor or shower drain. If

rodents are within the structure itself, the strainer plate prevents rodent access to the drainage system.

304.3 Meter boxes. Meter boxes shall be constructed in such a manner that rodents are prevented from entering a structure by way of the water service pipes connecting the meter box and the structure.

❖ The water service pipe may be tunneled into the building from the meter box. Where such an installation occurs, the annular space around the pipe must be protected to prevent rodents from getting into the building. This can be accomplished by a barrier to block their entry, such as a corrosion-resistant heavy wire screen or metal plate that is securely fastened in place.

304.4 Openings for pipes. In or on structures where openings have been made in walls, floors or ceilings for the passage of pipes, the annular space between the pipe and the sides of the opening shall be sealed with caulking materials or closed with gasketing systems compatible with the piping materials and locations.

❖ Rodents can enter a building through the annular spaces around piping that penetrates a wall, ceiling or floor. These spaces must be blocked using caulking or gasketing (see also commentary, Section 315).

SECTION 305
PROTECTION OF PIPES AND PLUMBING SYSTEM COMPONENTS

305.1 Protection against contact. Metallic piping, except for cast iron, ductile iron and galvanized steel, shall not be placed in direct contact with steel framing members, concrete or cinder walls and floors or other masonry. Metallic piping shall not be placed in direct contact with corrosive soil. Where sheathing is used to prevent direct contact, the sheathing shall have a thickness of not less than 0.008 inch (8 mil) (0.203 mm) and the sheathing shall be made of plastic. Where sheathing protects piping that penetrates concrete or masonry walls or floors, the sheathing shall be installed in a manner that allows movement of the piping within the sheathing.

❖ Metallic piping must be protected from external corrosion that could be caused by contact with steel framing members, walls and floors built of cinder(s) or concrete and other masonry units (such as brick). External corrosion could cause perforation of piping and tubing, resulting in a leak. An exception within the first sentence for not having to protect cast iron, ductile iron and galvanized steel piping from the indicated building elements recognizes that those piping materials have thick walls. Where corrosion at contact points might occur, experience has shown that the corrosion doesn't progress far enough to cause a problem with these thick-walled pipes.

The wall thicknesses of copper and copper-alloy tubing and piping are much less than the thicker-wall, protection-exempted piping. Copper against steel corrosion is caused by electrochemical potential between the two metals that, in the presence of an electrolyte (moisture from the air), results in the movement of copper ions to the steel [see Commentary Figure 605.24.1(4)].

Contact of copper with concrete or cinder walls and floors or other masonry (for example, brick) can cause copper to corrode. This is primarily because of the variety of sources of components that are used in the makeup of concrete and masonry. Cinders are sometimes used as an aggregate in lightweight (nonstructural) concrete for slab-on-grade floors and lightweight (nonstructural) "cinder blocks." Cinders are a byproduct created from the combustion of coal. Cinders sometimes contain sulfur compounds and, where exposed to moisture, these compounds can form acids that are corrosive to metals. Some concrete is made with fly ash that can also contain high levels of sulfur. Brick, other than concrete brick, is made from various types of clay soil, sand, lime, iron oxide, magnesia and sometimes fly ash. Sulfur in the presence of water (moisture in the air) creates various sulfuric compounds, including acids. Acids aggressively promote the transfer of copper ions away from copper products.

Copper and copper-alloy tubing and piping can be isolated (protected against contact) from the indicated building elements by providing a space or an isolating material between the piping and the building element. One method is to install the piping on mounting tracks, standoff brackets or hangers (of material compatible with copper). Where piping penetrates a steel framing member such as a stud, joist or track, isolation could be accomplished by installing a snap-in plastic fitting into a hole in the member to provide both support (see Section 308.5) and protection against contact with the member [see Commentary Figure 308.3(2)]. Where piping penetrates a concrete or masonry wall or floor, installation of a length of plastic pipe is a common method to protect the piping against contact with such building materials. Other methods might also be viable solutions for protecting against contact such as installing a length of foam insulation tube, plastic pipe, sheathing material or other arrangements that will stay secured in position, provide support for the piping (where support is required) and protect the piping against contact with the building element for the life of the installation. Note the requirements of Sections 305.3, 307.3 and 315.1 for additional or differing requirements for some penetrations.

Naturally corrosive soils can be found in many areas of the United States and in many other parts of the world. The areas can be very localized or exist over large regions. Such soils can corrode, in a short period of time, any type of unprotected metallic piping, not just those that are copper-based. Soils can also have fill materials containing furnace slag, cinders, fly ash or industrial byproducts that can be corrosive to buried metallic piping. The designer, installer or engineer should consult with soils engineers, piping manufacturers and local code officials to determine the need for protecting metallic piping from contact with soil or fill materials of potentially corrosive nature.

Where any type of metallic piping is buried in corrosive soil, preventing contact of piping with the soil is commonly accomplished by installing a sheathing of flexible plastic "sleeve" having an 8 mil (or greater) wall thickness. The 8 mil (0.008 inch) (0.203 mm) minimum thickness is a well-established installation recommendation by the cast and ductile iron piping industries based on over 50 years of experience in nearly every type of corrosive soil environment. Note that the piping manufacturer's installation instructions could have additional requirements for protecting the piping in these types of environments.

The sheathing on the piping need not be a single unbroken length of material for the entire piping run or necessarily be in a "tube-like" form as piping sizes and arrangements could make that difficult to accomplish in the field. Where the ends of individual sheathing sections meet, the ends are overlapped with the overlap typically maintained (during handling and backfill) by the application of self-adhering tape or cable ties (commonly called zip ties or tie wraps). Flexible plastic sheets (of 8 mil thickness) could also be used to wrap the piping in a similar manner of coverage. The latter method is usually preferred where the piping has branch runs, angle fittings or flanged piping connections. The plastic sheathing or sheeting need not be wrapped tightly around the piping as it is preferable to install the material somewhat loose to allow the piping to move within the sheathing. As this section does not require piping protection against ground water infiltration, the intent does not include making the overlaps or seams of the protective material watertight.

In service, piping and tubing can move slightly. The last sentence of this section requires that these movements be considered when installing sheathing. For example, wrapping plastic self-adhesive tape (a "sheathing" of sorts) around a pipe where it penetrates a concrete slab (either prior to casting of the concrete floor slab or through a hole drilled/cored after a slab is placed) will not allow movement of the piping within the sheathing.

Note that the selection of the type of plastic sheathing for plastic piping must be made carefully to prevent known material incompatibilities. Numerous CPVC pipe and tube manufacturers and flexible plastic sleeving manufacturers indicate that flexible PVC sleeving products (inherently having plasticizers to make the product flexible) should not be applied against or around CPVC piping materials. The plasticizers in the sleeving material could damage the CPVC piping. Flexible plastic sleeving is available in a polyethylene material (that doesn't have PVC plasticizers). However, as PVC flexible sleeving is still produced, the installer must be aware of what type of sheathing material is being used for protecting CPVC products and other plastic piping products. The plastic piping manufacturer's installation instructions must be followed in this regard.

305.2 Stress and strain. Piping in a plumbing system shall be installed so as to prevent strains and stresses that exceed the structural strength of the pipe. Where necessary, provisions shall be made to protect piping from damage resulting from expansion, contraction and structural settlement.

❖ A plumbing system must not be damaged by stresses, strains or movement of the building components. In piping systems, provisions must be made for the expansion and contraction of the pipes themselves. Each piping material has a different rate of expansion and contraction that must be considered when designing the restraint system for the piping and the structure that surrounds the piping system.

Changes in temperature can cause distortion of the pipe material; for example, heat causes the material to expand. The greatest amounts of expansion and contraction in piping will occur along the length of the pipe. Hot water piping can experience significant movements in short runs of piping. Though the amount of expansion per unit length is low, large movements can occur in long lengths of pipe. Commentary Figure 305.2(1) contains the expansion rate for various pipe materials.

The most common method to absorb thermal expansion in plumbing piping systems is through the installation of one or more offsets in the piping. The typical offset piping arrangements used are the "L" bend (1-elbow change in direction), the "Z" bend (2-elbow offset) and the "U" bend (4-elbow offset) [see Commentary Figures 305.2(1) through 305.2(4)]. The

PIPING MATERIAL	RATE OF THERMAL EXPANSION in/in/°F
Brass-red	0.000009
Copper	0.00001
Cast iron	0.0000056
Carbon steel	0.000005
Ductile iron	0.0000067
Stainless steel	0.0000115
Borosilicate (glass)	0.0000018
ABS	0.00005
CPVC	0.000035
HDPE	0.00011
PE	0.00008
PEX	0.00093
PP	0.000065
PVC	0.00004
PVDF	0.000096

Source: *Facility Piping Systems Handbook*, 2nd Edition, Frankel, McGraw Hill, 2002.

For SI: 1 inch = 25.4 mm, °F = 68°C + 32.

Commentary Figure 305.2(1)
THERMAL EXPANSION RATES FOR PIPING MATERIALS

length, L, in each of these figures is determined from the following equation:

$$L = [1.5 \times (E/S) \times D_o \times (G)]^{1/2}$$

where:

E = Modulus of elasticity at pipe temperature (psi)

S = Maximum allowable stress for the pipe material at the highest in-service pipe temperature (psi)

D_o = Outside diameter of pipe (inches)

G = Change in length of piping due to temperature change (inches). Thermal expansion rate of the pipe material from Commentary Figure 305.2(1) × Change in temperature of the pipe (installation day to highest in-service temperature expected) × Length of pipe in feet between points where the pipe is restricted from expanding in length × 12 inches per foot.

The values for E and S are obtained from piping manufacturers, engineering publications or the material standards for the pipe products.

Sample Problem: A 160-foot-long straight run of 1-inch copper tube size CPVC pipe is to be installed to convey hot water at 140°F. The ends of the piping will be attached to equipment. The temperature at the time of installation will be 50°F. Determine the required offset length, L, to accommodate the thermal expansion that will occur when the system is operating.

Problem Approach

Obtain the thermal expansion rate from Commentary Figure 305.2(1), calculate the amount of thermal expansion of the piping run, obtain the modulus of elasticity and allowable stress values from the piping manufacturer, and calculate the required offset length, L.

Solution

For CPVC piping material, the thermal expansion rate listed in Commentary Figure 305.2(1) is 0.000035 inches/inch/°F. The change in temperature of the pipe from installation to service condition is 140°F minus 50°F, which equals 90°F. The change in length of the pipe, G, is calculated as follows:

G = 0.000035 inches/inch/°F × 90°F × 160 feet × 12 inches per foot

G = 6.1 inches

The pipe manufacturer provides a modulus of elasticity of 3.23×10^5 psi and an allowable stress of 1000 psi, both at the service temperature of 140°F. The outside diameter of the pipe, D_o, is 1.125 inches. Therefore,

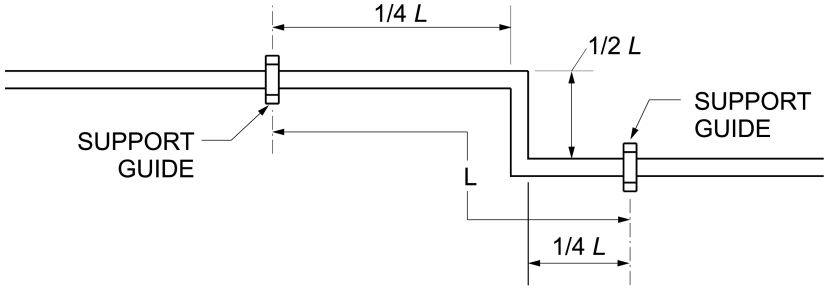
$L = [1.5 \times (E/S) \times D_o \times G]^{1/2}$

$L = [1.5 \times (3.23 \times 10^5 /1000) \times 1.125 \times 12.5]^{1/2}$

L = 57.7 inches

Piping expansion joint assemblies can also be used to absorb thermal expansion. These products are usually preengineered or they can be custom-engineered for any application. The code does not regulate the design or installation of expansion joint assemblies.

Commentary Figure 305.2(2)
"L" BEND



OFFSET PIPING MUST BE SUPPORTED WITH HANGERS, SLIDE PLATES OR SPRING HANGERS.

Commentary Figure 305.2(3)
"Z" BEND