

Polyethylene Water Service

Pipe and Tube Installation Guide



SCOPE

This guide presents recommendations for the installation of polyethylene (PE) piping intended for underground water supply for residential, rural and light commercial installations.

In keeping with generally accepted practices and the recommendations included in applicable standards of the American Water Works Association (AWWA), only PE pipe and tubing of not less than a 160 psi pressure rating for water at 73.4°F should be used for water service supply. This guide recommends that PE water service pipes only be installed underground, except for any necessary length above ground for making appropriate connections to other approved above ground water distribution piping.

IMPORTANT NOTICE

The statements and descriptions in this guide are informational only. They are not intended as an endorsement or warranty with respect to any product, component or system. The Plastic Pipe and Fittings Association (PPFA) and its members make no warranties or representations, expressed or implied, as to: the fitness of any product or system for any particular purpose; the suitability of any product or system for any specific application; or the performance of any product or system under actual service conditions.

In all cases, use of materials, details of installation, and methods of construction should be in accordance with the requirements of all applicable local codes and project specifications. In addition, the manufacturer's installation and product application recommendations should be followed. Applicable code requirements or regulations, project specifications and manufacturer's recommendations take precedence over any recommendations contained in this manual in the event there are conflicts.

This manual does not purport to address all of the safety concerns that may be associated with the use and installation of PE piping. It is the responsibility of the user and installer to use and install PE piping, and to use any necessary equipment, materials and tools, in accordance with appropriate safety and health practices and all regulatory limitations.

Suitability and Qualification for Potable Water Service. Most federal, state and other health authorities in the United States recognize the requirements for materials intended for the conveyance of potable water which have been established by NSF *International* under their ANSI/NSF Standard 14 (See *National Standards*). In Canada, the requirements are those of the Canadian Standards Association (CSA), and these are equivalent to those of NSF. PE pipe intended for potable water service is only made from NSF or CSA approved formulations. Such approval is generally signified by inclusion in the pipe markings of either the NSF or the CSA seal of approval (See *Product Identification*).

Installation in Soils Contaminated by Organics. PE materials, in common with other plastics and elastomers and porous materials such as concrete and asbestos cement, may be subject to permeation by certain solvents and petroleum products. When pipe is to be installed in soils which may contain organic pollutants such as solvents, heating oil, gasoline or other petroleum products, or their vapors, the manufacturer of the pipe or the piping component should be consulted prior to material selection regarding the risk of permeation. PE piping should not be installed in soils that contain, or are likely to contain, significant quantities of organic pollutants.

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PE water service.

BEFORE PROCEEDING WITH INSTALLATION OF A PE WATER SERVICE LINE

Before proceeding with the installation of a PE water service line, the installer should become familiar with the entire contents of this guide. Information included in different sections is often interrelated in its importance.

Prior to handling, working with, and installing PE water service pipe, the installer should become aware of the performance properties of PE piping which need to be considered and addressed to ensure a successful, durable application (See *Background Information*).

Also, prior to starting a job the installer should confirm that:

- The pipe and fittings to be installed comply with the requirements of the project, and with any applicable code requirements. For this purpose, pipe and fittings markings should be carefully checked (See *Product Identification*).

- The pipe markings do include a section noting that the pipe is suitable for potable water service.

- The fittings have been designed and sized to be compatible with the pipe dimensions (See *PE Pipe Dimensioning Systems*, and *Joining Methods & Fittings* and *Appendix: Pipe & Tube Dimension Ratio*).

- The pipe and fitting manufacturer's installation recommendations have been consulted and all those that are supplementary to these general recommendations have been noted.

- The maximum anticipated working and surge pressures and maximum anticipated operating temperatures are within the rated capacity of the pipe and fittings (See discussion in *Appendix: Pipe & Tube Pressure Rating, Pressure Class & Surge Pressure Tolerance*).

- The proposed routing of the service line – while largely dictated by expediency and economy – results in a minimum number of sharp changes in direction, with no bend having a smaller bending radius than recommended (See *Installation: Bends in Service Pipe*).

- The necessary equipment, tools and materials are available for achieving firm and stable support of the pipe at those points where it connects to rigid structures and a “protection sleeve” is available for placement over the tap connection at the main (See *Installation: Extraneous Loads*).

BACKGROUND INFORMATION ON PE PIPING

Polyethylene (PE) pipe was first commercially made in the 1940s, after World War II. Today, it is the second most widely used plastic pipe material, after polyvinyl chloride (PVC). These two materials account for over 90 percent of all currently produced plastic pipe.

PE is a non-conductor and therefore not susceptible to galvanic or electrochemical corrosion, the mechanism that limits the durability of buried metallic pipes. It is also unaffected by most acids, alkalis, and corrosive salts.

Its excellent toughness and flexibility distinguish PE. It is very resistant to damage by impact, even at lower temperatures. It is a ductile material that does not shatter even if punctured or cut regardless of service temperature. It withstands the effects of cyclic or repeated stressing (such as by water pressure surging). Its greater flexibility permits the coiling of smaller diameter pipes, which reduces fitting requirements and facilitates installation. PE pipe's toughness allows it to resist failure under the expansive action of freezing water.

To protect PE pipe during extended outdoor storage against the effects of the sun's ultraviolet (UV) radiation—which over time can damage most plastics—PE pipe compositions include additives that either physically screen or chemically absorb UV rays. The commonly used UV screen is finely divided carbon black, hence the black color of many PE pipes. Black PE pipe has excellent weathering resistance. Pipe made to other colors relies on stabilizers to absorb UV rays. Since these UV stabilizers are somewhat less effective than carbon black, non-black pipe should not be stored outdoors for extended periods (e.g., not longer than a few months) unless it is shielded against direct sunlight, as by the use of a tarp. Of course, once installed underground or away from sunlight, UV protection is no longer needed.

While PE pipe has sufficient strength, toughness, and chemical resistance for water service pressure piping in common with other plastics, it has certain limitations on its performance just as any other engineering material. These limitations include the following, which must be recognized and addressed to ensure a proper and durable installation:

- **Mechanical properties are temperature sensitive.** As temperature increases, PE becomes less strong and less stiff. For continuous use where the pipe temperature exceeds 80° F, the pipe pressure rating should be appropriately reduced (See *Appendix: Temperature Compensation*).

- **The coefficient of thermal expansion/contraction is higher than metal.** For the same change in temperature, unconstrained PE pipe expands about 8 times as much as metallic pipe. Installation must prevent the development of excessive pipe contraction forces which, while normally not damaging to the pipe, can produce higher than desirable pull-out and bending loadings at the point the pipe connects with a rigidly held fitting (See *Installation*).

- **Shear strength is relatively low.** Installation must avoid the development of high shear stressing, which can occur in a flexible pipe subject to overburden from above while connected to a fixed, immovable structure, such as a service tap on a water main (See *Installation: Extraneous Loads*).

- **Kinking can compromise mechanical properties.** Pipe should not be bent so tightly that it kinks either during handling or while in service (See *Installation: Bends in Service Pipe*).

- **Mechanical properties can also be compromised by gouging, cutting, and excessive abrasion.** PE pipe should be handled and installed to prevent the possibility of excessive damage. (See *Handling PE Pipe & Tubing*).

- **Certain solvents can permeate the pipe wall.** Plastic water service pipe, like most piping materials in general, should not be installed in soils which are contaminated, or can be subject to contamination, by organic solvents (See *Installation in Soil Contaminated by Organics*).

Chlorine used as a disinfectant must not exceed the requirements of ANSI/AWWA C 651, Standard for Disinfecting Water Mains. For potable water systems using chlorine as a disinfectant, the recommendation limits chlorine dosage to 25mg/l free chlorine with a residual of 10 mg/l at the end of a 24-hour stand. Daily amounts of chlorine should not exceed 3 ppm at temperatures in excess of 75° F.

Additional Information. PE piping is widely used for many other applications, including municipal water distribution systems; drop piping for submersible pumps; ground coupled heating/cooling systems; gas distribution; oil and gas production; gathering gas generated by landfills; conveying corrosive fluids; conveying slurries, sewerage, and drainage; and pipeline rehabilitation.



Persons interested in obtaining information on these uses or other technical information should contact PPA or any of its members, which manufacture PE pipe.

PE pipe and tubing is available in two diameter systems: standard controlled **inside** diameters and standard controlled **outside** diameters. In both systems, the pipe wall thickness is determined by the pipe's pressure rating: *the higher this rating, the thicker the wall*. In the case of pipe with standard controlled inside diameters, it is the outside diameter that is determined by the pipe wall thickness. And in the case of the pipe with standard controlled outside diameter, it is the inside diameter that varies depending on pipe wall thickness.

The inside diameter sizing system was established to accommodate the use of the barbed insert fitting. The standard controlled inside diameters are the same as the **inside** diameters of Schedule 40 iron pipe sizes (IPS).

Newer PE pipe and tubing favored for water service applications is made with controlled **outside** diameters. PE pipe and tubing made with controlled outside diameters is recommended for water service applications. This system is designed to accommodate newer mechanical and other joining systems that require a predictable outside diameter. In the case of pipe sizes, the standard outside diameters correspond to the **outside** diameters of Schedule 40 IPS steel pipe. In the case of tubing sizes, the standard outside controlled diameters are the same as those for copper tubing. This explains the often-used designation of copper tube sizes (CTS).

How to identify whether a pipe has been made with inside or outside controlled diameter. Pipe made with standard controlled **inside** diameters always includes the identification **IDR** (inside diameter ratio), or **SIDR** (standard inside diameter ratio) in its markings, followed by a number which states the diameter ratio. The diameter ratio of pipe made with controlled **outside** diameters is always simply reported as either **DR**, or **SDR**. (See *Product Identification* and *Appendix* for more discussion on pipe diameter ratio).

It is also helpful to remember that pipe made to ASTM D 2239 is only made with standard controlled **inside** diameters; whereas pipe made to ASTM D 3035 is only made with controlled **outside** diameters.

NATIONAL STANDARDS UNDER WHICH PE WATER SERVICE PIPING IS MADE

North American standard specifications which define the dimensional and other requirements of PE pipe and tubes follow:

ASTM D 2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR) Based on Controlled Inside Diameter (only covers pipes with controlled **inside** diameters).

ASTM D 3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter (only covers **pipes** with **outside** controlled diameters).

ASTM D 2737, Standard Specification for Polyethylene (PE) Plastic Tubing (only covers **tubing** with **outside** controlled diameters).

CSA 137.1, Polyethylene Pipe Tubing and Fittings for Cold Water Pressure Services (covers **pipes** with controlled **inside and outside** diameters and **tubing** with controlled **outside** diameters).

AWWA C 901, AWWA Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½-inch through 3-inch, for Water Service (covers **pipe** with controlled **inside and outside** diameters and **tubing** with controlled **outside** diameters).

ANSI/NSF Standard 14, Plastic Piping System Components and Related Materials (includes material requirements intended to ensure water quality and product quality assurance criteria).

PRODUCT IDENTIFICATION

Pipe Markings. PE pipe and tubing should be marked in compliance with the marking requirements of the referenced standard. By applying these markings the manufacturer affirms that the pipe has been manufactured, inspected, sampled, and tested in accordance with – and has been found to meet – the requirements of the referenced specification.

ASTM, AWWA, NSF and CSA standards require that markings on pipe and tubing be present at frequent intervals – generally not less than every 5 feet – and that they include at least the following items of information:

- The nominal pipe or tubing size (e.g., 1-inch);
- The type of PE material from which the pipe is made (e.g., PE 3408 – consult the *Appendix* for information on the PE material designation system);
- The pipe or tubing dimension ratio (e.g., IDR or SIDR if made with controlled inside diameters; or DR or SDR if made with controlled outside diameters. Consult the *Appendix* for information on standard diameter ratios for PE pipe and tubing); or the pipe pressure rating or pressure class for water for 73° F (e.g., 160 psig); or both;
- The standard against which the pipe has been made and tested;
- The manufacturer’s name or trademark, and production record code; and
- The seal or mark of the certification agency that has determined the suitability of the pipe for potable water service. Figure 1 shows how markings appear on a pipe.

Fittings markings. There are a variety of different fittings which may be used to join PE water service pipe. Mechanical, butt fusion, and insertion fittings should be marked in accordance with the industry standards to which they are produced. At a minimum, all fittings used for PE water service pipe should be clearly marked with the manufacturer’s name or trademark and some indication as to the nominal size of the pipe for which they are designed.

General. Protective packaging (coil wrappings, strapping, etc.) should not be removed until pipe is required for use. Care should be taken not to throw the pipe or drag it over rough terrain, rocks, or any surface which can cut, puncture, gouge, or otherwise damage the pipe. Excessive bending should be avoided, and care should be taken when “peeling” pipe from coils, so that it does not buckle and kink. Kinked and damaged pipe sections, including those that have been cut or gouged to a depth of more than about 10 percent of the pipe wall thickness, should be removed.

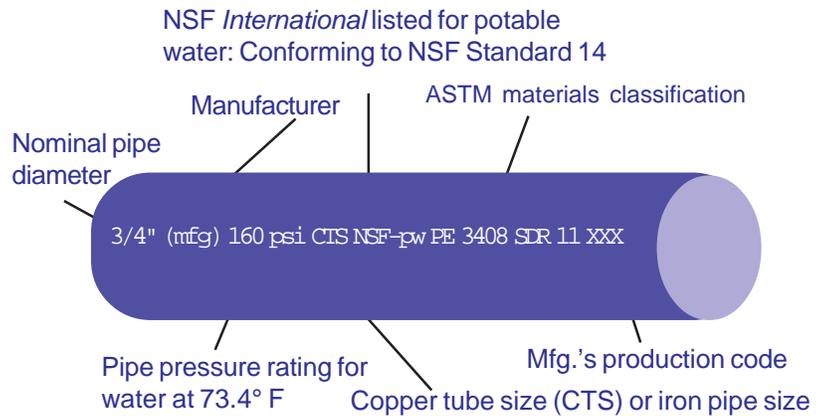


Figure 1: PE pipe markings

Releasing coils. Care should be used in unwrapping or unstrapping coils. Pipe held in wrapped or strapped coils can be under tension. If wrapping is removed or strapping is cut incorrectly, the suddenly released tension could cause the coiled pipe to react in a potentially hazardous manner. Strapped coils often have additional strapping on individual layers. Strapping should be removed carefully, taking care to control the pipe as it is being released. In the case of coils with multiple strap-

Do's AND DON'TS ON HANDLING

Do

- ✓ Store pipe on firm and flat surfaces.
- ✓ Keep pipe and fittings away from sharp objects, heat, and toxic and aggressive materials.
- ✓ Take care not to cut, kink, abrade, or otherwise damage the pipe during handling.
- ✓ Keep protective packaging intact until pipes and fittings are required for use.
- ✓ Release coils carefully, keeping in mind they may be coiled under tension.
- ✓ Take care when handling pipe under wet or frosty conditions, as the pipe may become slippery.
- ✓ Temporarily cap cut pipe ends to prevent dirt or other material from entering the pipe.
- ✓ Uncoil pipe and allow it to warm in the sun before burial for ease of installation.

DON'T

- ✓ Throw pipe from delivery vehicles.
- ✓ Drag pipe or roll pipe coils.
- ✓ Place pipe and fittings in contact with lubricating oil, gasoline, solvents, or other aggressive materials.
- ✓ Heat pipe with an open flame.

ping, the outer strapping should be removed first, and the other straps removed to only release the length of pipe immediately needed.

INSTALLATION

Above ground section. Some installations require a short length of the pipe to be located above ground for connection to other approved water distribution piping. In such cases, the PE pipe should be located so it is away from any sources of heat, not subject to mechanical damage such as cutting and abrading, and not at risk of contact with solvents, petroleum products and other chemicals.



Installation of PE pipe in trench.

PE pipe that terminates above ground outdoors should be encased in a suitable sleeve (e.g., a short section of a metal or rigid thermal plastic pipe) to protect it against mechanical damage and ultraviolet radiation.

PE pipe passing through any concrete floor or masonry wall should be wrapped with a flexible material, not less than ¼ inch thick, to minimize the risk of abrasive action resulting from pipe movement by thermal expansion/contraction.

Pipe routing, trenching, and embedment materials. The routing and final location of a PE water service pipe is governed largely by expediency and economy. While the straightest run is generally preferable, this may not always be practicable due to surface and subsurface obstructions, or existing pipe services. Required changes in direction should not be “tighter” than the minimum allowable bending radius for the particular pipe or tubing being installed (See *Table I* for minimum bending radii for PE pipe and tubing). Tighter bending radii are best accommodated by the use of change of direction fittings.

Trench bottoms should provide stable and uniform support to the pipe over its entire length. They should be free of lumps, rocks, or other material which could damage the pipe or cause localized overstressing. Do not use blocking to change pipe grade or to intermittently support pipe across excavated sections.

Pipe may be installed in a wide range of native soils. The pipe embedment materials should be stable, sufficiently granular to be easily worked under the sides and bottom of the pipe to achieve uniform support, and readily compactable to the soil densities specified by contract documents or other applicable requirements.

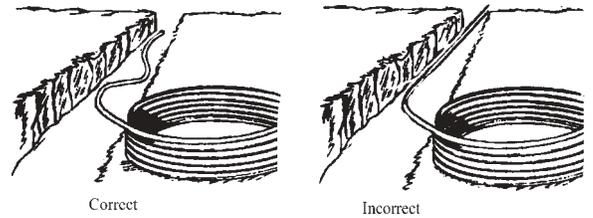


Figure 2: Correct and incorrect snaking

Embedment materials should be free of refuse, organic material, or frozen solids. The particle size of the material in contact with the pipe should not exceed ½ inch, and the particles should not have sharp surfaces that may easily abrade the pipe.

Water service pipe should be installed below the frost line. A minimum of 18 inches of cover is recommended to protect it from activities such as digging and anticipated vehicular traffic.

Laying the pipe. Pipe should be laid with moderate slack, or snaking, to accommodate any contraction resulting from cooling *prior to backfill*. The slack also provides for active soil friction development once the pipe is buried and placed in service. This soil friction helps to reduce stress concentration at terminations and/or connection of the pipe when service temperatures fluctuate during operation.

To reduce tension stresses due to thermal contraction, pipe should be allowed to cool in the trench before backfilling. To minimize the development of pull-out stresses at rigid connections, such as service tees and meters, pipe should be trimmed to required length and connected to rigidly held fittings only after it has cooled substantially close to the trench temperature. Unconstrained PE pipe will contract approximately 1 inch in length per 100 feet of pipe for each 10° F temperature drop.

Bends in service pipe. Gradual changes in direction may be made by bending PE pipe. The bending radius

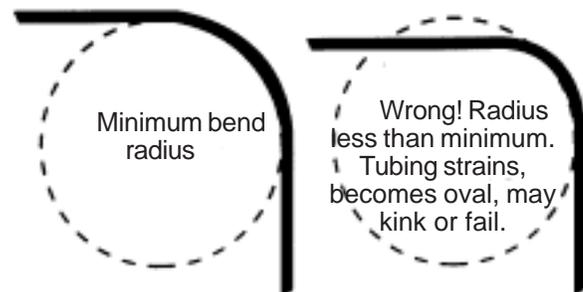


Figure 3: Bending radius of PE pipe.

Table 1: Minimum Bending Radii for PE Pipe and Tubing

NOMINAL PIPE OR TUBING SIZE (IN.)	MINIMUM BENDING RADIUS (IN.)
1/2	20
3/4	30
1	36
1 1/4	42
1 1/2	54
2	72
2 1/2	84
3	100

should not be less than about 30 times the pipe diameter (See Table 1) or the coil radius when bending with the coil. To minimize the chances of kinking the pipe, do not bend the pipe in a radius tighter than that of the coil (See Figure 3).

*When bending PE pipe in the same direction as it has been coiled in the factory, the minimum radius may be as small as that of the coil.

Bends near fittings or valves should not be made closer than 10 pipe diameters to minimize bending stresses at the point the pipe enters the connection.

Extraneous loads. Points of connections between flexible PE pipe and a rigidly held structure – such as at a tap or next to a basement wall through which a pipe enters – can often be subject to differential soil settlement that causes excessive localized shear, bending, and pull-out forces. Experience has shown that transitions from flexible pipe to rigidly held structures are critical junctions.

To avoid potential problems, the following precautions are recommended:

- Take extra care during bedding and backfilling to provide firm and uniform support for the pipe (See Figure 4).
- If appropriate to minimize deflection at the tee outlet, tap the main so that the service line comes off at an angle slowly rising from the horizontal.
- Place a protective sleeve or shield (which can consist of a short section of plastic pipe split lengthwise) over the tapping tee connection and short section of pipe (See Figure 5).

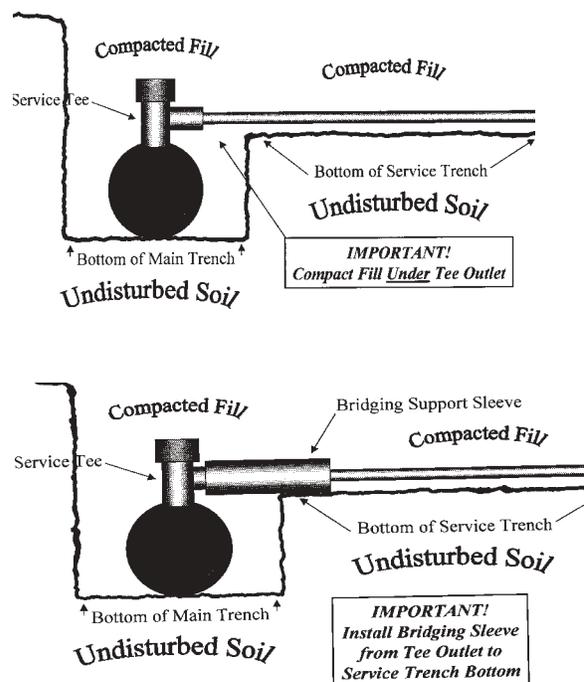
Backfill materials and their placement. Initial backfill should satisfy requirements for embedment materials, as described above. The initial backfill should cover the pipe by at least 4 inches. However, if pressure testing is to be conducted, leave the joints and fittings exposed until after pressure testing to facilitate inspection for leakage (See Pressure Testing).

The final backfill may consist of any material acceptable to the governing authority. However, any large rocks, stones, frozen clods, and other debris greater than 3 inches in diameter should be removed. Backfill should be placed and spread in uniform layers and compacted to the minimum density as specified by contract documents, or by the appropriate government jurisdiction.

Installation under or in concrete slabs. Pipe which will be covered by concrete floors or slabs should be placed in firm, smooth trench bottoms, which provide stable, uniform support. Concrete may be poured directly over the pipe, although most installations bury the pipe in backfill material to hold the pipe in place.

PE pipe may also be completely embedded in concrete. Pipe sections that run through expansion joints should be covered by a sleeve which can consist of a short length of larger diameter pipe – to avoid possible overstressing at these points, in case these joints separate or otherwise move. In addition, at all points where PE pipe transitions from rigid concrete to more flexible soil, the pipe should be encased in a short length of protective sleeving.

Figures 4 (below) & 5(botton): Connecting PE to a tap or other rigidly held structure.



Installation in unstable soils. Because of its flexibility and adaptability to soil movement, PE pipe may be installed in unstable materials such as swamps and “expansive soils.” However, when installing PE pipe in such materials, special care must be taken to preclude the possibility that even a minor shifting of the pipe could cause localized overstressing at points where the pipe is anchored, or is connected to fixed rigid structures. Provide sufficient flexibility in the installation layout to avoid this possibility. For such installations a qualified professional should establish the specific construction requirements.

Installation through boreholes. Because of its flexibility and availability in longer lengths, PE pipe is often installed into boreholes made by directional drilling. These boreholes must be free of sharp rocks or debris that can cut or otherwise damage the pipe. In some soils it may be necessary to grout the hole to prevent collapse prior to pipe installation. Grouting also helps reduce the friction while pulling the pipe.

The pulling load on PE pipe should not exceed the Safe Pull Strengths listed in Table 2. Larger pulling loads can result in permanent

*Table 2: Safe Pull Strength (in pounds of pulling force)
PE Water Service Pipe & Tubing Made to Standard Outside Diameters*

Nominal size	SDR 11 Pipe or Tubing		SDR 9 Pipe or Tubing	
	PE 2406	PE 3408	PE 2406	PE 3408
1/2-inch pipe	200	245	240	295
3/4-inch pipe	310	385	375	460
1-inch pipe	490	605	585	720
1 1/4-inch pipe	820	1010	935	1150
1 1/2-inch pipe	1030	1265	1225	1510
2-inch pipe	1605	1975	1915	2360
3-inch pipe	3485	4285	4160	5120
1/2-inch tubing			130	160
3/4-inch tubing	220	270	260	320
1-inch tubing	360	440	430	530
1 1/4-inch tubing	540	660	645	790
1 1/2-inch tubing	750	925	900	1105
2-inch tubing	1285	1580	1530	1885

CHECK LIST FOR PROPER PIPE INSTALLATION:

- ✓ Provide stable and continuous support to the pipe over its entire length.
- ✓ Place pipe in trench with moderate slack (e.g., by gradual snaking).
- ✓ Allow the pipe to cool to trench temperature prior to trimming it and connecting it to rigidly held fittings.
- ✓ Do not allow pipe bends within 10 pipe diameters of a fitting or connection to a rigid structure.
- ✓ Do not bend pipe tighter than the recommended minimum bending radius for the pipe being installed. Bend with the coil whenever possible.
- ✓ Provide a firm and stable foundation under pipe sections next to rigidly held fittings, where pipes enter rigid structures, or wherever differential soil settlement could occur.
- ✓ Prevent excessive bending and shear stresses at taps, by placing a short section of protective sleeve over the tap connection and short section of water service pipe.
- ✓ Place select backfill next to the pipe for proper support and protection.
- ✓ Conduct pressure test prior to final backfilling.

stretching, with accompanying wall thinning at some point in the pipe. When the pulling load remains under the Safe Pull Strength, some stretching does occur. After pulling is complete, the pipe soon relaxes to its original pre-pull length. To accommodate any contraction and facilitate final tie-in, PE pipe should be pulled slightly beyond its target connection point.

When pulling equipment is able to generate a larger force than the pipe’s Safe Pull Strength, the pulling force should be limited by a device such as a hydraulic pressure regulator, a load sensor, or a “fuse” consisting of a smaller sized or a thinner walled PE pipe just ahead of the pipe being pulled. This “fuse” is often referred to as a “weak link.”

Other “No-Dig” installations. PE service pipes can be installed by a variety of other “no-dig” techniques, such as by planting or plowing. Those interested in learning about these methods should contact PPFA.



Figure 6: Mechanical or compression insert fittings.

JOINING METHODS & FITTINGS

Polyethylene pipe or tubing can be joined to other PE pipe or fittings or to pipe or appurtenances of other materials using one or more joining systems. The purchaser should verify with the pipe and fittings manufacturer that fittings are capable of restraining PE pipe or tubing from pullout, especially for larger-diameter products with thicker walls. In the case of mechanical coupling or compression fittings, make sure that the manufacturer recommends its fittings for polyethylene water service piping. Further information and specific procedures may be obtained from the pipe and fittings manufacturers.

Preparation of pipe ends. First, the pipe must have square-cut ends for proper joint makeup. PE pipe may be cut with a saw, knife, run-around cutter, or guillotine shears. The latter two techniques are preferred because they result in square-cut ends with no chips or shavings that can get inside the pipe. Pipe cutters that are designed for metal pipe are not recommended because they tend to severely distort the cut ends of the pipe. Any burrs on the cut surfaces should be removed with a chamfering tool, reamer, knife, or fine-tooth file.

Second, the cut ends of PE pipe should be clean, dry, and free of any surface defects that might impair the tightness of the connection. Dust and light soiling may generally be removed by wiping with a clean, dry, lint-free cloth. Heavier soiling may be scrubbed-off with a wet synthetic or natural bristle brush, followed by thorough rinsing with clean water. Chemical or petroleum-based solvents should not be used.

Unless specifically recommended by the joining system's manufacturer, no pipe dope, gasket lubricant, oil, grease, soap, detergent, or other material should ever be applied on a pipe surface for facilitating insertion into a fitting or for any purpose.

Mechanical or Compression fittings. (See Figure 6).

Mechanical or compression fittings are being increasingly used with PE water service pipes. The words mechanical and compression are used interchangeably when describing these fittings. Designs are available to fit pipe and tubing made to controlled inside and also to controlled outside diameters. When choosing fittings, make sure they are sized for the pipe, or tubing, with which they will be used. Most importantly, check to see that the fitting manufacturer specifically recommends the use of its fittings for PE water service piping applications.

Compression fittings accomplish the functions of pressure seal and pullout resistance through a variety of proprietary designs. They all require an internal tubular stiffener to support the PE pipe against compressive forces and for gripping. If loose stiffeners are used in the makeup of a compression joint, make sure that the end of the stiffener has no sharp edges and that the stiffener does not extend beyond the clamp or coupling nut. Some proprietary mechanical fitting designs have self-contained "floating" stiffeners which compensate for the stiffener's extension beyond the end of the fitting (See Figure 7). Again, check to see that the fitting is designed for use in PE water pressure piping systems. If loose stiffeners (not self-contained in the fitting), use only stiffeners approved by the fitting manufacturer. Because the exact pipe/fitting assembly procedure can vary depending on fitting design, the user should obtain this information from the fitting manufacturer, and the fitting manufacturer's directions should be closely followed.

Heat Fusion Fittings. Connections of two PE pipes to each other, or between a PE pipe and a PE fitting, can also be made by the use of one of two heat fusion methods, hot plate fusion (including butt, socket, or saddle fusion) or electrofusion.

These methods involve preparing PE pipe surfaces, heating the surfaces to proper fusion temperatures, and joining the surfaces in a prescribed manner to effect the fusion bond. ASTM D 2657 describes the hot-plate heat-joining practice; ASTM F 1290 describes the electrofusion method. Detailed procedures vary depending on the specific equipment and materials involved. Special tools to provide heat and alignment are required for heat-fusion connections. These tools are available from the fusion joining system's manufacturer. Those



Figure 7: Insert fittings with self-contained floating stiffeners.

interested in using heat-fusion procedures may obtain further information by contacting PPA or manufacturers of the PE piping systems.

Insert fittings. Insert fittings are perhaps the oldest method for joining PE water service pipe. This method is intended to be used only with PE piping with controlled inside diameters, that is with pipe that carries IDR, or SIDR markings. Check that the manufacturer recommends the specific insert fitting joining method for PE water service piping, and make sure that the manufacturer's joining methods are followed. (See *National Standards*).

Flaring. Flare joints are generally not recommended with PE tubing. Consult the manufacturer or its literature concerning acceptable practice with flare joints.

The following methods cannot be used to join PE pipe:

■ **Threading.** Threading cannot be used to join PE pipe, tubing, or fittings for pressure rated applications.

■ **Solvent Cement.** Solvent cement methods cannot be used to join PE pipe, tubing, or fittings

New Technologies. At the time of this writing, there are a number of new technologies being introduced for the mechanical joining of PE water service pipe. Installers are encouraged to consult manufacturers' installation and product recommendations.

PRESSURE TESTING

During pressure testing, take safety precautions to protect personnel in case of pipe pullout or failure. Pipe should be adequately anchored by placement of sufficient back-fill to arrest excessive pipe movement. However, joints and fittings should be left exposed to inspect for leaks and for joint tightening if necessary. Pressure testing should only be conducted with water. Compressed air or other gases are not recommended.

Slowly fill the pipe with water, taking care to prevent surges and air entrapment. All entrapped air should be released before pressure testing.

The duration of the test and the test pressure should meet the requirements of the applicable regulation, construction specification, or contract document. In the absence of such, it is recommended that PE pipe be pressure tested for a minimum of one hour, but not to exceed three hours, at 150% of the anticipated maximum system operating pressure, but not less than 15 psi above that value. The test pressure should not be in excess of the pressure rating of the pipe, or that of the fittings or appurtenances which have not been isolated from the pressure test.

All visible leaks should be repaired and the line retested by repeating the same procedure.

DISINFECTION

Disinfection of PE pipe should be carried out in accordance with ANSI/AWWA C 651, Standard for Disinfecting Water Mains. However, when disinfecting PE pipe, the disinfectant solution should be limited to a maximum concentration of 100 parts per million of chlorine in water, and at this concentration the disinfection period should not exceed 3 hours. The solution should be premixed before injection into the pipe.

At the end of the disinfection period, all lines should be thoroughly flushed. Disinfectant solution should never be left in PE pipe for extended periods of time.

CHECK LIST: MAKING JOINTS WITH PE PIPE

- ✓ Make sure the fitting is the appropriate design and dimensions for the pipe controlled diameter (inside or outside) and wall thickness.
- ✓ Study the fitting manufacturer's instructions and recommendations for proper joining procedure.
- ✓ Prepare the pipe end properly:



- ✓ Cut pipe with square ends.
- ✓ Remove cutting chips or any other foreign material from pipe end.
- ✓ Check pipe end for nicks, cuts or other surface



defects which could compromise quality of seal.

- ✓ Assemble joint in accordance with applicable directions.



APPENDIX

1. PE Material Classification and Design Stress.

Polyethylene pressure-rated pipe materials are designated using an abbreviated terminology (PE) as specified in accordance with ASTM D 1600 “Standard Terminology Relating to Abbreviations, Acronyms, and Codes for Terms Relating to Plastics” followed by a four-digit number (examples: PE 2406, PE 3408).

- The first two digits following the PE abbreviated terminology typically represent the grade designation as defined in section 4.3 of ASTM D 3350 “Standard Specification for Polyethylene Plastics Pipe and Fittings Materials” (examples: PE 24, PE 34).

- The first numerical digit of the grade designation represents the density cell as specified in Table 1 of ASTM D 3350 and the second numerical digit of the grade designation represents the resistance to slow crack growth (ESCR or PENT) as specified in Table 1 of ASTM D 3350.

- The last two digits of the material classification represent the Plastic Pipe Institute’s (PPI) recommended maximum hydrostatic design stress (HDS) for water at 73° F (23° C) divided by one hundred.

The following two designations of PE materials are used for water service piping applications:

- PE 2406: This is a PE pipe material that is classified by ASTM D 3350, Standard Specification for Polyethylene Plastic Pipe and Fitting Materials as follows: The first number in the code, 2, designates a type II medium density polyethylene with a 0.926-0.940 grams/cc density. The second number, 4, designates a grade 4 with an ESCR F 20 > 600 hrs. The third and fourth numbers, 06, designate a 630 psi hydrostatic design stress for water at 73° F.

- PE 3408: This is a PE pipe material that is classified by ASTM D 3350, Standard Specification for Polyethylene Plastic Pipe and Fitting Materials as follows: The first number in the code, 3, designates a type III high-density polyethylene with a 0.941 to 0.965 grams/cc density. The second number, 4, designates a grade 4 with an ESCR F 20 > 600 hrs. The third and fourth numbers, 08, designate an 800 psi hydrostatic design stress for water at 73° F.

2. Maximum recommended HDS at 73° F (800 psi).

The hydrostatic design stress (HDS) is the maximum allowable tensile stress in the wall of a pipe, in the circumferential orientation, due to internal hydrostatic pressure that can be applied continuously with a high degree of certainty that failure of the pipe will not occur during the intended service life. The hydrostatic design stresses for plastic pipe are established from results of long-term pressure testing as specified in ASTM D 2837

“Standard Method for Obtaining Hydrostatic Design Basis (HDB) for Thermoplastic Pipe Materials.” The HDS is determined by multiplying the HDB by a design factor which takes into consideration all the variables and degrees of safety involved in a thermoplastic pressure piping installation.

Pipe & Tube Dimension Ratio. The thicker the wall of a pipe compared to its diameter, the greater is its capacity to safely resist internal pressure. In the case of all plastic pipes, the ratio of pipe diameter to wall thickness – called the *diameter ratio* (DR) – is used to identify a pipe’s relative wall thickness. The smaller the DR, the thicker the wall is in respect to a pipe’s diameter.

The norm is to apply the DR designation to the ratio of a pipe’s controlled outside diameter to its wall thickness. Because PE pipe may also be made with controlled inside diameters, the relative wall thickness of such pipes is denoted by their **inside dimension ratio** (IDR) (see *Figure 10*). For purposes of product simplification, uniformity and standardization, ASTM has established a set of preferred, or standard, pipe diameter ratios. These have been labeled as **standard dimension ratios** (SDR), when based on controlled **outside** diameters, and **standard inside dimension ratios** (SIDR), when based on controlled **inside** diameters. Accordingly, the inclusion of SDR or SIDR in a PE pipe’s markings gives a quick and sure means for determining the controlled diameter system to which the pipe was made.

DIMENSION RATIO

Polyethylene pipe design is based on the “Dimension Ratio” of the pipe, typically abbreviated as “DR”. By definition, dimension ratio is the ratio of the pipe’s outside diameter to its minimum wall thickness. This ratio may also be referenced as the “SDR” or “Standard Dimension Ratio” of the pipe.

Where: SDR = Standard Dimension Ratio (also called Dimension Ratio)

OD = Pipe outside diameter, inches

t = Pipe minimum wall thickness, inches

For ID controlled pipe manufactured to ASTM D 2239, this ratio may be referenced as the “SIDR” or “Standard Inside Dimension Ratio” of the pipe.

Where: SIDR = Standard Inside Dimension Ratio

ID = Pipe inside diameter, inches

t = Pipe minimum wall thickness, inches

Figure 10: Dimension Ratio

3. Pipe & Tube Pressure Rating. A PE pipe’s pressure rating for water at ambient temperature is determined by the pipe’s hydrostatic design stress (HDS) and its relative wall thickness; that is, its diameter ratio (DR). Since PE pipe is made from materials with two standard stresses (630 and 800 psi), and to *specified* standard dimension ratios (DRs or SIDRs as the case may be), this results in a limited number of standard pipe pressure ratings which are listed in Table 3. Pressure ratings are always marked on the pipe as well.

4. Pressure Class (PC) & Surge Pressure Tolerance. Standards issued by the American Water Works Association (AWWA) identify the pressure capacity of a pipe by means of its pressure class (PC). The PC is the pipe’s pressure rating (PR) less any required allowance to compensate for possible effects on the pipe’s strength by repetitive pressure surges that can typically occur in water works distribution systems. Because of this allowance, the PC in accordance with AWWA is generally a lower value than the pipe’s PR, in accordance with the ASTM system. However, in the case of PE its surge pressure capacity is such that no surge allowance is required. Therefore, the PC for PE water service pipe is always the same value as its PR.

PE’s tolerance for safely resisting pressure surging is reflected by the following guideline in AWWA C 901, AWWA Standard for Polyethylene (PE) Pressure Pipe and Tubing, ½-inch through 3-inch, for Water Service: The sum of the system working pressure (i.e., the maximum

Table 3: PE Water Service Pipe * Pressure Rating versus Product SDR or SIDR

Pressure rating (psi) for water at 73.4 F	Pipe SIDR (Applies to pipe made with controlled inside diameters)		Pipe or Tubing SDR (Applies to pipe or tubing with controlled outside diameters)	
	PE 2406	PE 3408	PE 2406	PE 3408
160	7	9	9	11
200		7		9

**The pressure ratings shown in this table are recommended for water service applications. Lower pressure rated PE pipes are available and are used for yard, sprinkler, and other less demanding applications not covered by this manual.*

sustained operating pressure exclusive of pressure surges) and the maximum anticipated surge pressure should not exceed 1.5 times the pipe’s nominal PC (or, pipe’s PR, as explained above).

5. Temperature Compensation. The standard pressure rating (PR) and pressure class (PC) for PE pipe is calculated at the standard rating temperature of 73.4° F. As explained in AWWA C 901: Polyethylene piping intended for use where service temperatures may exceed this value for prolonged period should have a hydrostatic basis (HDB) established in accordance with ASTM D 2837 for the specified (or higher) temperature. An elevated temperature HDB value can be obtained from the pipe manufacturer for the specific polyethylene resin being used. An elevated temperature pressure class can then be calculated using either Eq 1 or Eq 2 (Sec. 3(10)) with the elevated temperature HDB used as the value for HDB in the equations.

An alternative method of establishing an elevated temperature pressure class (PC) for temperatures between those for which HDB values have been determined is to multiply the 73.4° F (23° C) PC value by an interpolated temperature compensation factor recommended by the manufacturer. When this information is not readily available, the conservatively established ratings given in Table 4 may be used.

Table 4: Pressure Ratings (PR) for Elevated Temperatures

Temperature	PE @ Base Temperature of 73.4° F	
	160 psi	200 psi
Up to 80° F	160 psi	200 psi
81° to 90° F	130 psi	160 psi
91° to 100° F	115 psi	140 psi
Over 100° F	*	*

**The strength of PE pipe above 100° F can vary from one commercial grade to another. The pipe manufacturer should be consulted for the recommended multiplier for the particular pipe being installed.*

*Table 5: Pipe Made to Standard Outside diameters
200 psi, PE 3408 per ASTM D 3035*

Dimensions, inches					
NOMINAL SIZE, IN.	AVG. OD. IN.	APPROX. ID, IN.	MIN. WALL THICKNESS	APPROX. WEIGHT LBS/100'	STANDARD COIL LENGTH IN FEET
3/4	1.050	0.816	0.117	10.0	100 & 500
1	1.315	1.023	0.146	17	100 & 300
1-1/4	1.660	1.292	0.184	26.0	100 & 300
1-1/2	1.900	1.478	0.211	36.0	100 & 300
2	2.375	1.597	0.264	61.0	100 & 300

*Table 6: Tubing Made to Standard Outside Diameters
200 psi, CTS-OD PE 3408 per ASTM D 2737 Tubing: CTS-OD, SDR-9*

Dimensions, inches					
NOMINAL SIZE, IN.	OD, IN.	APPROX. ID, IN.	MIN. WALL, IN.	APPROX. WEIGHT LBS/100'	STANDARD COIL LENGTH IN FEET
3/4	0.875	0.681	0.097	10.2	100 & 500
1	1.125	0.875	0.125	16.8	100 & 300
1-1/4	1.375	1.069	0.153	25.2	100 & 300
1-1/2	1.625	1.263	0.181	35.8	100 & 300
2	2.125	1.653	0.236	60.3	100 & 300

*Table 7: Pipe Made to Standard Inside Diameters
200 psi, PE 3408 per ASTM D 2239 IPS-ID, SDR-7,*

Dimensions, inches					
NOMINAL SIZE, IN.	OD. IN.	APPROX. ID, IN.	MIN. WALL THICKNESS, IN.	APPROX WEIGHT, LBS/100'	STANDARD COIL LENGTH, FEET.
3/4"	0.824	1.060	0.118	15.2	100 & 400
1"	1.049	1.349	0.150	24.3	100 & 300
1-1/4"	1.380	1.774	0.197	41.8	100 & 300
1-1/2"	1.610	2.070	0.230	58.9	100 & 300
2"	2.067	2.657	0.295	9.3	100 & 300

*Table 8: Iron Pipe Size per ASTM D 3035 SDR 11 Pipe 160 psi
Maximum Operating Pressure*

NOMINAL OD, INCHES	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, INCHES	0.840	1.050	1.315	1.660	1.900	2.375	3.500
SDR	11	11	11	11	11	11	11
MIN WALL, INCHES	0.076	0.095	0.120	0.151	0.173	0.216	0.318
AVERAGE ID, INCHES	0.681	0.851	1.066	1.346	1.541	1.926	2.838
GPM	Head Loss (ft/100' of pipe)						
1	0.637	0.215	0.072	0.023	0.012	0.004	0.001
2	2.300	0.777	0.260	0.084	0.043	0.015	0.002
3	4.874	1.646	0.551	0.177	0.092	0.031	0.005
4	8.303	2.804	0.938	0.302	0.157	0.053	0.008
5	12.552	4.239	1.418	0.456	0.237	0.080	0.012
6	17.594	5.941	1.988	0.640	0.332	0.112	0.017
7	23.408	7.904	2.644	0.851	0.441	0.149	0.023
8	29.975	10.121	3.386	1.090	0.565	0.191	0.029
9	37.281	12.589	4.212	1.356	0.793	0.237	0.036
10	45.314	15.301	5.119	1.648	0.854	0.288	0.044
11	54.062	18.255	6.107	1.966	1.019	0.344	0.052
12	63.515	21.447	7.175	2.310	1.197	0.404	0.061
13	73.665	24.874	8.322	2.679	1.389	0.469	0.071
14	84.502	28.533	9.546	3.073	1.593	0.538	0.082
15	96.019	32.422	10.847	3.491	1.810	0.611	0.104
16	108.210	36.538	12.224	3.935	2.040	0.689	0.104
17	121.067	40.880	13.676	4.402	2.282	0.771	0.117
18	134.586	45.445	15.204	4.894	2.537	0.857	0.130
19	148.760	50.231	16.805	5.409	2.804	0.947	0.144
20	164.585	55.237	18.480	5.948	3.084	1.041	0.158
21	179.055	60.460	20.227	6.511	3.375	1.140	0.173
22	195.165	65.900	22.047	7.097	3.679	1.242	0.188
23	211.912	71.555	23.939	7.705	3.994	1.349	0.204
24	229.291	77.423	25.902	8.337	4.322	1.459	0.221
25	247.298	83.504	27.936	8.992	4.661	1.574	0.239

*Table 9: Iron Pipe size per ASTM D 3035 SDR 9 Pipe
200 psi Maximum Operating Pressure*

NOMINAL OD, INCHES	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, INCHES.	0.840	1.050	1.315	1.660	1.900	2.375	3.500
MIN WALL, INCHES	0.093	0.117	0.146	0.184	0.211	0.264	0.389
AVERAGE ID, INCHES	0.646	0.807	0.011	1.276	1.461	1.826	2.691
GPM	HEAD LOSS (FT/100' OF PIPE)						
1	0.825	0.279	0.093	0.030	0.016	0.005	0.001
2	2.980	1.006	0.337	0.108	0.056	0.019	0.003
3	6.314	2.132	0.713	0.230	0.119	0.040	0.006
4	10.757	3.632	1.215	0.391	0.203	0.068	0.010
5	16.262	5.491	1.837	0.591	0.307	0.104	0.016
6	22.793	7.696	2.575	0.829	0.430	0.145	0.022
7	30.324	10.239	3.426	1.103	0.572	0.193	0.029
8	38.832	13.112	4.387	1.412	0.732	0.247	0.037
9	48.298	16.308	5.456	1.756	0.910	0.307	0.047
10	58.704	19.822	6.632	2.135	1.107	0.374	0.057
11	70.037	23.469	7.912	2.547	1.320	0.446	0.068
12	82.284	27.784	9.295	2.992	1.551	0.524	0.079
13	95.432	32.224	10.781	3.470	1.799	0.607	0.092
14	109.471	36.964	12.367	3.981	2.064	0.697	0.106
15	124.392	42.003	14.052	4.523	2.345	0.792	0.120
16	140.185	47.335	15.836	5.097	2.642	0.892	0.135
17	156.842	52.960	17.718	5.703	2.956	0.998	0.151
18	174.355	58.873	19.696	6.340	3.287	1.110	0.168
19	192.718	65.074	21.771	7.008	3.633	1.227	0.186
20	211.923	71.559	23.940	7.706	3.995	1.349	0.204
21	231.964	78.326	26.204	8.435	4.372	1.476	0.224
22	252.835	85.373	28.562	9.194	4.766	1.609	0.244
23	274.530	92.699	31.013	9.982	5.175	1.747	0.265
24	297.045	100.301	33.556	10.801	5.599	1.891	0.287
25	320.372	108.178	36.191	11.649	6.039	2.039	0.309

*Table 10: Copper Tube Sized per ASTM D 2737 SDR 11
Pipe 160 psi Maximum Marketing Pressure*

NOMINAL OD, INCHES	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, INCHES	0.625	0.875	1.125	1.375	1.625	2.125	3.125
SDR	11	11	11	11	11	11	11
MIN WALL, INCHES	0.057	0.080	0.102	0.125	0.148	0.193	0.284
AVERAGE ID, INCHES	0.507	0.710	0.912	1.115	1.318	1.723	2.534
GPM	HEAD LOSS (FT/100' OF PIPE)						
1	2.685	0.522	0.154	0.058	0.026	0.007	0.001
2	9.693	1.886	0.555	0.209	0.093	0.025	0.004
3	20.540	3.996	1.176	0.443	0.197	0.053	0.008
4	34.993	6.808	2.004	0.755	0.335	0.091	0.014
5	52.900	10.291	3.030	1.141	0.506	0.137	0.021
6	74.148	14.425	4.247	1.600	0.710	0.192	0.029
7	98.647	19.191	5.650	2.128	0.944	0.256	0.039
8	126.324	24.575	7.235	2.725	1.209	0.408	0.062
9	157.116	30.566	8.999	3.390	1.504	0.408	0.062
10	190.969	37.151	10.938	4.120	1.828	0.496	0.076
11	227.835	44.324	13.049	4.915	2.181	0.591	0.091
12	267.674	52.074	15.331	5.775	2.562	0.695	0.106
13	310.445	60.395	17.781	6.698	2.971	0.806	0.123
14	356.116	69.280	20.397	7.683	3.408	0.924	0.141
15	404.653	78.722	23.177	8.730	3.873	1.050	0.161
16	456.029	88.717	26.119	9.839	4.365	1.183	0.181
17	510.215	99.258	29.223	11.008	4.883	1.324	0.203
18	567.188	110.342	32.486	12.237	5.428	1.472	0.225
19	626.922	121.963	35.908	13.526	6.000	1.627	0.249
20	689.397	134.117	39.486	14.873	6.598	1.789	0.274
21	754.592	146.800	43.220	16.280	7.222	1.958	0.300
22	822.487	160.008	47.109	17.745	7.782	2.134	0.327
23	893.063	173.739	51.151	19.267	8.547	2.317	0.355
24	966.303	187.987	55.346	20.848	9.248	2.507	0.384
25	1042.190	202.750	59.692	22.485	9.975	2.704	0.414

*Table 11: Copper Tube sized per ASTM D 2737 SDR 9
Pipe 200 psi Maximum Operating Pressure*

Nominal OD, inches	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, inches	0.625	0.875	1.125	1.375	1.625	2.125	3.125
SDR	9	9	9	9	9	9	9
Min wall, inches	0.069	0.097	0.125	0.153	0.181	0.236	0.347
Average ID, inches	0.481	0.673	0.865	1.057	1.249	1.634	2.403
GPM	Head Loss (ft/100' of pipe)						
1	3.479	0.677	0.199	0.075	0.033	0.009	0.001
2	12.558	2.443	0.719	0.271	0.120	0.033	0.005
3	26.609	5.177	1.524	0.574	0.255	0.069	0.011
4	45.333	8.819	2.596	0.978	0.434	0.118	0.018
5	68.531	13.332	3.925	1.479	0.656	0.178	0.027
6	96.058	18.687	5.502	2.072	0.919	0.249	0.038
7	127.796	24.862	7.320	2.757	1.223	0.332	0.051
8	163.651	31.837	9.373	3.531	1.5666	0.425	0.065
9	203.542	39.598	11.658	4.391	1.948	0.528	0.081
10	247.398	48.129	14.170	5.338	2.368	0.642	0.098
11	295.159	57.421	16.905	6.368	2.825	0.766	0.117
12	346.769	67.461	19.862	7.481	3.319	0.900	0.138
13	402.180	78.241	23.035	8.677	3.849	1.044	0.160
14	461.345	89.751	26.424	9.953	4.415	1.197	0.183
15	524.225	101.984	30.025	11.310	5.017	1.360	0.208
16	590.782	114.932	33.838	12.746	5.654	1.533	0.235
17	660.980	128.589	37.858	14.260	6.326	1.715	0.263
18	734.787	142.947	42.-86	15.853	7.032	1.907	0.292
19	812.173	158.002	46.518	17.522	7.773	2.107	0.323
20	893.109	173.747	51.154	19.268	8.548	2.317	0.355
21	977.568	190.178	55.991	21.091	9.356	2.537	0.388
22	1065.525	207.290	61.029	22.988	10.198	2.765	0.423
23	1156.956	225.077	66.266	24.961	11.073	3.002	0.460
24	1251.838	243.535	71.700	27.008	11.981	3.248	0.497
25	1350.149	262.661	77.331	29.129	12.922	3.503	0.536

Table 12: Iron Pipe sized per ASTM D 2239 SDR 9 Pipe
160 psi Maximum Operating Pressure

NOMINAL OD, INCHES	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, INCHES	0.766	1.014	1.292	1.699	1.982	2.545	3.777
SIDR	9	9	9	9	9	9	9
MIN WALL, INCHES	0.069	0.092	0.117	0.153	0.179	0.230	0.341
AVERAGE ID, INCHES	0.622	0.824	1.049	1.380	1.610	2.067	3.068
GPM	HEAD LOSS (FT/100' OF PIPE)						
1	0.991	0.252	0.078	0.021	0.010	0.003	0.000
2	3.579	0.911	0.281	0.074	0.035	0.010	0.002
3	7.583	1.930	0.596	0.157	0.074	0.022	0.003
4	12.920	3.288	1.016	0.268	0.126	0.037	0.005
5	19.531	4.971	1.536	0.404	0.191	0.057	0.008
6	27.376	6.968	2.153	0.567	0.268	0.079	0.012
7	36.421	9.270	2.864	0.754	0.356	0.106	0.015
8	46.640	11.871	3.667	0.966	0.456	0.135	0.020
9	58.008	14.765	4.561	1.201	0.567	0.168	0.025
10	70.507	17.946	5.544	1.460	0.690	0.204	0.030
11	84.119	21.411	6.614	1.742	0.823	0.244	0.036
12	98.827	25.155	7.771	2.046	0.967	0.287	0.042
13	113.619	29.174	9.013	2.373	1.121	0.332	0.049
14	131.481	33.466	10.339	2.722	1.286	0.381	0.056
15	149.401	38.027	11.748	3.094	1.461	0.433	0.063
16	168.370	42.856	13.239	3.486	1.647	0.488	0.071
17	188.376	47.948	14.813	3.901	1.842	0.546	0.080
18	209.410	53.302	16.467	4.336	2.048	0.607	0.089
19	231.465	58.915	18.201	4.793	2.264	0.671	0.098
20	254.531	64.786	20.015	5.270	2.490	0.738	0.108
21	278.602	70.913	21.907	5.769	2.725	0.808	0.118
22	303.669	77.294	23.878	6.288	2.970	0.881	0.129
23	329.726	83.926	25.927	6.827	3.225	0.956	0.140
24	356.767	90.809	28.054	7.387	3.489	1.035	0.151
25	384.785	97.940	30.257	7.968	3.764	1.116	0.163

*Table 13: Iron Pipe sized per ASTM D 2239 SDR 7 Pipe
200 psi Maximum Operating Pressure*

Nominal OD, inches	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	3"
OD, inches	0.807	1.069	1.361	1.790	2.088	2.681	3.980
SDR	7	7	7	7	7	7	7
Min wall, inches	0.089	0.118	0.150	0.197	0.230	0.295	0.438
Average ID, inches	0.622	0.824	1.049	1.380	1.610	2.067	3.068
GPM	Head Loss (ft/100' of pipe)						
1	0.991	0.252	0.078	0.021	0.010	0.003	0.000
2	3.579	0.911	0.281	0.074	0.035	0.010	0.002
3	7.583	1.930	0.596	0.157	0.074	0.022	0.003
4	12.920	3.288	1.016	0.268	0.126	0.037	0.005
5	19.531	4.971	1.536	0.404	0.191	0.057	0.008
6	27.376	6.968	2.153	0.567	0.268	0.079	0.012
7	36.421	9.270	2.864	0.754	0.356	0.106	0.015
8	46.640	11.871	3.667	0.966	0.456	0.135	0.020
9	58.008	14.765	4.561	1.201	0.567	0.168	0.025
10	70.507	17.946	5.544	1.460	0.690	0.204	0.030
11	84.119	21.411	6.614	1.742	0.823	0.244	0.036
12	98.827	25.155	7.771	2.046	0.967	0.287	0.042
13	114.619	29.174	9.013	2.373	1.121	0.332	0.049
14	131.481	33.466	10.339	2.722	1.286	0.381	0.056
15	149.401	38.027	11.748	3.094	1.461	0.433	0.063
16	168.370	42.856	13.239	3.486	1.647	0.488	0.71
17	188.376	47.948	14.813	3.901	1.842	0.546	0.080
18	209.410	53.302	16.467	4.336	2.048	0.607	0.089
19	231.465	58.915	18.201	4.793	2.364	0.671	0.098
20	254.531	64.786	20.015	5.270	2.490	0.738	0.108
21	278.602	70.913	21.907	5.769	2.725	0.808	0.118
22	303.669	77.294	23.878	6.288	2.970	0.881	0.129
23	329.726	83.926	25.927	6.827	3.225	0.956	0.140
24	356.767	90.809	28.054	7.387	3.489	1.035	0.151
25	384.785	97.940	30.257	7.968	3.764	1.116	0.163

8. Sources of Standards & Other Information. Sources of standards referenced by this guide and of other information relating properties, design and installation of PE water service piping are as follow:

American Society for Testing and Materials (ASTM)

100 Barr Harbor Drive
West Conshocken, PA 19428

American Water Works Association (AWWA)

6666 West Quincy Avenue
Denver, CO 80235
www.awwa.org

Canadian Standards Association (CSA)

178 Rexdale Blvd.
Rexdale, Ontario M9W 1R3
Canada
www.csa.ca

NSF International

3475 Plymouth Road
PO Box 130140
Ann Arbor, MI 48113
www.nsf.org

Plastics Pipe Institute (PPI)

Division of the Society of the Plastics Industry (SPI)
1801 K Street, NW Suite 600K
Washington, DC 20006
www.plasticpipe.org

PPI issues various technical reports dealing with thermoplastics piping.



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