Installation Guide for iPVC Pipe

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CHAPTER 1
GENERAL INFORMATION

Polyvinyl Chloride (PVC) pipes were first manufactured in Germany in 1935 and were introduced in the United States in 1952. Today, it has become one of the world’s most widely used and recognized thermoplastic pipe materials. Due to its engineering properties, PVC pipe can be found in different business applications such as pressure-rated gas and oil, recycled water, sanitary and drinking water pipeline systems.

Reported benefits of PVC pipe include the following

- **Resistance to Aggressive Environment** – PVC pipe has shown resistance to rusting, pitting, corrosion, tuberculation or supporting biological growth and too many chemical compounds.
- **Life Cycle and Construction Cost Savings** – For utility applications, the life cycle and construction cost of PVC pipe can be significantly less than other pipe materials. Properties such as comparatively light weight, ductility and flexibility facilitate unique and cost-effective installation applications. Its aforementioned resistance to corrosion provides expectation of a long life in many environments.
- **Durability** – PVC pipe installations are cost-effective and have long-term cost advantages due to the pipe’s physical properties, and reduced maintenance costs (corrosion, leaching).
- **Permeation** – PVC offers greater permeation resistance for gasoline and water solutions such as benzene and toluene than Polyethylene (PE) pipe (Uni-Bell, 2012)

### 1.1 SIZES, SPECIFICATIONS, AND PRESSURE RATINGS OF iPVC PIPE

The iPVC pressure pipe is manufactured using ASTM D1784 PVC compounds and cell classification 12454 materials. The iPVC pipes are available in diameters 4, 6, 8, 10 and 12 inches and manufactured in accordance to with AWWA C900 and ISO guidelines. These pipes are currently being manufactured by Pyungwha Pipe Inc. (PPII) in South Korea and are sold in Korea, China, and Japan. Pipe specifications are shown in Table 1.1.

<table>
<thead>
<tr>
<th>Pipe Size (inch)</th>
<th>O D (inch)</th>
<th>Wall Thickness (inch)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Tolerance</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>Tolerance</td>
</tr>
<tr>
<td>4</td>
<td>4.8</td>
<td>±0.009</td>
</tr>
<tr>
<td>6</td>
<td>6.9</td>
<td>±0.011</td>
</tr>
<tr>
<td>8</td>
<td>9.05</td>
<td>±0.015</td>
</tr>
<tr>
<td>10</td>
<td>11.1</td>
<td>±0.015</td>
</tr>
<tr>
<td>12</td>
<td>13.2</td>
<td>±0.015</td>
</tr>
</tbody>
</table>

**Length**: 20 ft ± 1 in.

**Source**: Data from PPII

Table 1.2 compares testing results from iPVC pipe in comparison to the AWWA C900 standard.
<table>
<thead>
<tr>
<th>Engineering Properties</th>
<th>AWWA C900 Pipe (JM Eagle, 2016)</th>
<th>iPVC Pipe</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Test at 73 F</td>
<td>7000 psi</td>
<td>7,930 psi</td>
<td>13% increase in strength over the standard</td>
</tr>
<tr>
<td>Modulus of Elasticity</td>
<td>400,000 psi</td>
<td>461,000 psi</td>
<td>15% more ductile than the standard</td>
</tr>
<tr>
<td>Impact Test at 73 F</td>
<td>200 foot pounds</td>
<td>1,200 foot pounds no failure</td>
<td>At least 12 times more resilient than the standard</td>
</tr>
<tr>
<td>Hydrostatic burst test</td>
<td>755 psi</td>
<td>1,030 psi</td>
<td>37% higher than the standard</td>
</tr>
<tr>
<td>Pipe Stiffness</td>
<td>364 psi</td>
<td>451 psi</td>
<td>24% more stiffer than the standard</td>
</tr>
<tr>
<td>Sustained Pressure Test</td>
<td>73°F, 500 psi, 1000 hours</td>
<td>No failure</td>
<td>Pass</td>
</tr>
<tr>
<td>5 Second Burst Test</td>
<td>73°F, 470 psi</td>
<td>No failure</td>
<td>Pass</td>
</tr>
<tr>
<td>Acetone Immersion Test</td>
<td>20 minutes</td>
<td>No cracking</td>
<td>Pass</td>
</tr>
<tr>
<td>Vice Flattening Test</td>
<td>No Cracks</td>
<td>No Cracks</td>
<td>Pass</td>
</tr>
<tr>
<td>Temperature of Deflection</td>
<td>-</td>
<td>-</td>
<td>Pass</td>
</tr>
<tr>
<td>Flammability Test</td>
<td>-</td>
<td>-</td>
<td>Pass</td>
</tr>
<tr>
<td>Izod Impact Test / 73 degrees F</td>
<td>-</td>
<td>-</td>
<td>Pass</td>
</tr>
<tr>
<td>HDS Testing 2000h / 10000h</td>
<td>-</td>
<td>4200 psi</td>
<td>Pass</td>
</tr>
<tr>
<td>Working pressure</td>
<td>73°F (% of rating at 73°F)</td>
<td>100%</td>
<td>Slightly higher than conventional PVC but lower than comparable PE pipe</td>
</tr>
<tr>
<td></td>
<td>80°F (% of rating at 73°F)</td>
<td>88%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100°F (% of rating at 73°F)</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td>Coefficient of thermal expansion</td>
<td>$6.7 \times 10^{-5}$  in/inch/degree F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coefficient of flow</td>
<td>$C = 150$</td>
<td>$C = 150$</td>
<td>Standard PVC value</td>
</tr>
<tr>
<td>Manning N Value</td>
<td>$N = 0.009$</td>
<td>$N = 0.009$</td>
<td>Standard PVC value</td>
</tr>
</tbody>
</table>

The following is a partial summary of the PVC standard documents applicable to iPVC pressure pipe.

- C605 - Underground Installation of Polyvinyl Chloride (PVC) and Molecularily Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
- C900 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 inch through 60 inch (100 mm through 1,500 mm), for Water Transmission and Distribution
- AWWA Manual M23 - PVC Pipe - Design and Installation

### 1.2 PRESSURE RATINGS

The iPVC pipes are manufactured to meet or exceed AWWA Standard C900. The AWWA standard established pressure ratings of PVC pipe as a function of the dimension ratio (DR) of the pipe. Presently the iPVC is manufactured as DR 14, DR 18, and DR 25 pipe.
1.3 MARKING

1.3.1 PVC Pipe Marking

It is mandatory for all the manufacturers to label the PVC pipe wall at frequent intervals to be compliance with ASTM, AWWA, and NSF standards. Typically labeling will be made on the exterior surface of each pipe segment. PPI imprints the following items of information on every PVC pipe (see Figure 1.1):

- The manufacturer’s name or trademark
- The nominal pipe size (e.g., 8-inch);
- The type of PVC material (e.g., D17454)
- The pipe dimension ratio or the pipe pressure rating or AWWA pressure class for 73°F water, or both (PC 235)
- The standard against which the pipe has been made and tested (AWWA C900)
- Production record coding the place and time of manufacture
- The seal or mark of the certification agency that has determined the suitability of the pipe for potable water service (NSF 61)

In addition, the pipe should have a solid circumferential line drawn on the spigot end to show to extent of the insertion into the adjoining bell at installation.

Source: Courtesy of American Water.

Figure 1.1 PPI manufacturer marking configuration on PVC pipe
CHAPTER 2
SAFETY

2.1 PERSONAL SAFETY

Safety is the highest priority and field personnel should take responsibility for their own personal safety and their fellow installation crewmembers. It is always recommended to wear appropriate personal protective equipment (PPE) on the job and to be aware of the potential hazards working with pipe. Potential hazards of the operation, materials, equipment, and environment should be established before work begins, and plans should be made to minimize these hazards. Proper highway safety programs must be identified and in operation at all times. For more information, please refer to appropriate safety guidelines provide by the installer, the manufacturer and OSHA.

2.2 PERSONAL PROTECTIVE EQUIPMENT

PPE materials, hard hats, safety vests and steel-toed/composite-toed safety shoes are requirements at the job site. Workers must wear hard hats, vests, eye-protection, gloves, and recommended safety shoes during loading or unloading iPVC pipe and fittings in storage areas and pipe yards, during installation, operating the equipment and other areas where overhead hazards and low overhead clearance exist. Steel-toed/recommended composite toed safety shoes should be worn at all times. While using pneumatic tools such as pavement breakers and tamping machines, proper eye protection, gloves and ear protection must be employed. When cutting, trimming, or tapping pipe, safety glasses and gloves must be worn. Safety vests must be worn by all the project participants including engineers, consultants, and inspectors while on job site especially when working near traffic or at night. Long sleeve clothing should be worn when needed to protect from sunburn.

2.3 JOB SITE SAFETY

Before work begins at the job site, the potential hazards should be identified and discussed with the crew and observers on the job. Check the work site for hazards created by unguarded machinery, chemicals and fuels, heat, excessive noise, nearby equipment, existing buried pipes, cables and or power lines. Specific plans should be made to minimize such hazards. Documenting these plans and posting them in a public place may be beneficial to those involved in the operations and public at large.

The public should be restrained from getting to close to the defined work area. Field personnel should avoid working alone or arrange for periodic safety contacts. Field personnel should have call numbers at hand when required for emergency medical service and support.

The guidelines of OSHA as well as state and local regulatory agencies on trench construction requirements must be followed. The trench should be dug to the required alignment and depth (or as shown on the contract drawings) or as directed by the supervising engineer. Excessive runs of unsupported open trench should be avoided to minimize such problems as trench flooding, caving of trench walls and the freezing of the trench bottom and backfill material. Principal considerations in trench construction are trench width, stability of the native soil, stability of trench walls and water accumulation in the trench. Ladders are mandated in a deep trench to
allow quick exit. The OSHA website and *Handbook of PVC Pipe Design and Construction* provides additional information on the construction practice. The field engineers/project engineer must verify the desired OSHA certifications of all the workers before they are hired to perform the work. Any injuries or accidents must be logged, reported, and investigated as per OSHA guidelines (Uni-Bell, 2012).

Ice, snow, and rain are not harmful to iPVC components but precipitation usually make the job site more challenging for handling pipe, equipment, and personnel. Unsure footing and traction require greater care and caution to prevent damage or injury. Inclement weather can make pipe surfaces slippery. Workers should not walk on iPVC pipe at any time, but this is especially true when your footing is poor (PPI 2009). After heavy rain, if the trench is flooded, use pumps to dewater the trench and check the stability of the trench walls before working. Workers must consider that plastic pipe can float in water in installations in heavy rain or high water tables.

### 2.4 NOTIFICATION TO WORK SAFELY

Obtain all necessary permits from the local city/county/state agencies and notify the residents prior commencing the project execution. During execution of the job, provide proper signs, barricades, and traffic control at prominent locations.

When cutting the pipe with power equipment, keep feet in the clear and block the pipe so it will not move during cutting. Wear protective equipment and never leave tools lying about. (JM Eagle, 2016). Check the power tool wiring if used for proper grounding before the work begins, especially when water is present. When conducting live tapping on the pipe for service connections, use appropriate tapping machine recommended for iPVC pipe (controlled by yoke and feed-nut). Avoid drilling directly to the pipe or tapping tool used on ductile iron pipe. Using inappropriate tool may induce additional stress on pipe and cause failure. During installation, stay clear from construction equipment such as backhoe, trucks, or loaders etc.

### 2.5 GENERAL PRECAUTIONS AND PRACTICES

It is the responsibility of the worker to know and follow safe practices. Safe practices can be found from equipment suppliers/manufacturers, local authorities with jurisdiction pertaining to operating safely, and applicable regulations and codes.
CHAPTER 3
RECEIVING, STORING, AND HANDLING IPVC PIPE

3.1 RECEIVING

IPVC pipes are manufactured in diameters 4 inch and provided in 18-20 foot pipe lengths. Before the pipes are stored in their designated storage areas, the pipes must be inspected. Each pipe should be inspected for damage with any pipe damaged during the shipping set aside. Check the quantities against the shipping list including gasket material and lubricants. Notify the manufacturer/ distributor regarding the damaged or missing pipes.

3.2 HANDLING PRECAUTIONS

It is the receiver’s (contractor or owner) responsibilities to handle and store the material properly pending installation. Once the shipping items are properly off loaded and secured it is the liability of the installer (whether owner or contractor) to handle the pipe, store and install properly. According to PPI’s Field Manual for Municipal Application (2009), practical precautions must be followed during handling of material:

- Only persons directly needed to unload pipe, such as the equipment operator, should be allowed near the unloading area. All other personnel must stay well clear. If the public approaches a work area, they must be engaged and properly advised about the construction area and where practical should be prevented access by barricade or warning tape.
- Use appropriate equipment to unload the pipe.
- IPVC pipe is slippery when wet. Use caution at all times, especially in rainy or snowy weather.
- Although IPVC is highly impact resistant, place the pipe carefully on the ground; do not drop the pipe from the truck
- Prior to receiving material, make sure the unloading area is cleared and properly level (storing in the jobsite) for the pipe.
- The truck should be parked on level ground wherever possible. If temporary ramps are constructed to provide a level area, the ramp must be checked before the receiving the material.
- Store only in the designated areas. Pipe should be blocked to prevent rolling.

3.3 HANDLING RECOMMENDATIONS

Off-loading the pipes must be done using appropriate equipment. The equipment must be operated by experienced operators with sufficient operating space must be available for the operator and must be free from workers and obstacles. Proper signs boards and signs must be posted in unloading area at the time of off-loading material. If the unloading area becomes busy, additional appropriately attired staff must be used to control the traffic for the unloading period. Equipment operator must have sufficient line of sight and swing radius to operate the equipment. The operator must be aware of the maximum lifting capacity of the equipment and must not lift
above designed capacity. Figure 3.1 illustrates typical forklift handling of the iPVC pipe at the construction site.

![Figure 3.1 Loading and unloading using forklift](image)

*Source: Courtesy of American Water.

**Figure 3.1 Loading and unloading using forklift**

### 3.3.1 Unloading Equipment

Safe use of unloading equipment is the responsibility of the operator. The procedures for handling iPVC pipe include:

- If forklifts are used, check the forks for sharp edges that could damage the iPVC. Remove abrasive locations or use a suitable protective covering to prevent possible gouging of the pipe;
- The equipment should be positioned in the widest possible separation;
- The pipe should be lifted from the center of the pipe at the center of the equipment;
- Forks/slings should be inserted slowly underneath the pipe; do not twitch or ram them;
- Operate the forks as close to the ground as possible when moving pipe from one location to another, but do not allow the pipe to drag or scrape along the ground. (PPI, 2009)

### 3.3.2 Cold Weather Handling

The engineering properties such as, impact and flexibility are reduced in the colder temperature and making the pipe material more brittle though in the case of iPVC the difference is not as impactful as with conventional PVC. It is advised to handle the iPVC pipe properly during cold weather and assume significant impact while handling can damage the pipe.
3.4 STORING

The pipes and its fittings should be inspected visually for any damages and defects before storing. As noted previously, any damaged pipe/fittings must be set aside to avoid placing it in the trench. If the pipe is to be returned to the vendor/distributor, the receiver should note invoice and packing slip information, parts or batch numbers and the date material was delivered. Damage or questionable material must not be put into storage or contact the vendor directly for the next steps. Any damage which reduces the pipe wall thickness or properties of pipe may impair long-term service life has to be discarded.

3.4.1 Warehouse Storage

Pipes should be segregated based on pipe size and pressure. Pipe material that can be stacked because of its size or shape should be stored on shelves capable of supporting the combined weight of the materials. The pipes must be stacked properly in layers with suitable separators used between each row of the stacked pipes. Appropriate end stoppers (bracing) must be provided.

3.4.2 Job Site Storage Guidelines

Job site storage is recommended when the warehouse/storing place is far from the job site. The pipes must be stored on the level ground; the surface must be free from debris, rocks, or any other material, which could damage the pipe when placing on the ground. The pipes need to be stored on firm, stable surface. If the ground cannot be made level, use wooden plank or prepare a levelled surface. When pipes of variable wall thickness and size (DR) are received, it is recommended that the pipe be segregated into piles, each pile containing a single size and pressure rating to minimize confusion later. It is recommended to stack the pipe pile in the shape of pyramid with the bottom layers properly braced.

3.4.3 Outdoor Storage

iPVC pipes does modestly expand and contract as a function of temperature but not to the same extent as PE pipe. iPVC pressure pipe can be damaged by prolonged exposure to the sun and the pipes stored outside for extended time (months) must be covered to protect it from UV rays.
CHAPTER 4
INSTALLATION

The general installation of iPVC pipe and joining are addressed in this chapter. This chapter also includes overview of bedding, trenching and backfilling methodology followed in the iPVC installation. Please use the current AWWA C605, appropriate engineering drawings and specification for detail procedure.

4.1 iPVC PIPE INSTALLATIONS

4.1.1 Design

Prior to installation of iPVC pipe the installer must be understand:

- the scope of the project, location, existing ground conditions and bypass service lines to the customers
- the need to inspect pipes and fittings before they are installed
- the maximum operating and surge pressure of the system and adequacy of the pipes and fittings
- safety issues

4.1.2 Installation

The iPVC pipes connections are achieved by simple bell and spigot homing. The pipes are clearly marked as to the extent of insertion for the pipe (to avoid over or under insertion). This pipe is typically installed as an open cut or open trench installation. The iPVC pipes are not recommended for trenchless application at this time. The open cut is most conventional method of installation pipes. The open cut installation involves the listed:

4.1.2.1 Site Preparation

The site has to be prepared before placing iPVC pipes. Prepare logistic plan, clearing site including obtaining permits from local cities, obtaining location information on other utilities, and rerouting any utility or underground infrastructure before installing the iPVC pipe.

4.1.2.2 Trenching

The width of the trench is driven by the size of the pipe. As a rule of thumb, the typical trench width is 12 inches greater than the outside diameter of the pipe. The trench width and depth are project specific and it is always recommended to refer engineering drawings for trench details relative top depth. If the pipes must be placed below the frost line. The prepared trench must be free from water, dewater using pumps and prepare the trench for installation. If the trench bottom is not sufficient to support the pipe uniformly, proper bedding material must be used to provide support along the trench bottom. Appropriate cushioning material for the pipe must be provided between the hard foundation and the pipe to avoid additional stress on the iPVC pipe. Trench depth should be adjusted at the bell so the pipe and bell rests uniformly at the bottom of the trench.
4.1.2.3 Pipe Placement and Connections

The iPVC pipes are to be handled with proper care regardless of season during handling or lowering the pipe to the trench. Appropriate equipment and lifting accessories (slings, ropes, etc.) must be used to lift the pipes and placed in the trench to avoid pipe damage. If the pipes are placed manually in the trench, the pipe is required to rest carefully and not to be dropped. If the installation of iPVC pipe is exposed to higher temperature (sitting in the sun, hot summer day, etc.), the installer should be aware that iPVC pipe tends to expand longitudinally. It is highly recommended the pipes be allowed to cool before achieving connection or backfilling the trench. The direct exposure of the pipe to sun can be avoided by covering the pipe with colored tarps with sufficient ventilation. During winter or wet weather, installation the pipe is slippery and proper care must be considered while lowering the pipe manually or mechanically. iPVC pipe is more brittle during winter or extreme cold weather but is significantly more resilient than conventional PVC. Nonetheless, brittleness increases pipe stiffness, tensile strength and reduces the impact strength of the pipe. Hence, proper care of the pipe is necessary during loading, unloading, or lowering to the trench and during tapping the pipes for service connections.

The installer should inspect the bell end and spigot ends for any anomalies and damage. Inspecting the bell end (including the gasket) and spigot ends of pipes provides opportunity to clean the pipe of dirt, debris, and impurities. The cleaned pipe receives the appropriate amount of lubrication to attain a smooth connection. If the full length of pipes is not used, the spigot end of pipe must be square cut, chamfered (tapered). Lubrication is applied to the spigot end to achieve a successful connection with pipe or fittings.

Control valves, safety valves, fire hydrants and appropriate PVC fittings (molded fittings should be in conformance with AWWA C907. Fabricated fittings and valves must have same or higher pressure class than the iPVC. Please refer to engineering drawings for additional details. It may be necessary to cut the spigot end and bevel the iPVC to connect fittings.

Following are to be verified before placing and connecting the new iPVC pipe:

- Trench bed has to be prepared and compacted to provide firm base
- The pipe has been set below the frost line
- The trench is sufficiently dewatered before and during pipe installation
- Bell and spigot ends have been cleaned before applying lubrication. The spigot ends are cut square or beveled as necessary followed by lubrication before joining to fittings.
- Pipe and fittings are carefully joined to achieve proper connection
- Pipe is inserted properly, not over or under inserted (stop at the markings if a whole segment is used).
- Bends, control valves, safety valves and fire hydrants are inspected prior to installation. Proper restraining of joints is provided as necessary especially near bends, at pipe termination, hydrants, valves, and the joints.

4.1.2.4 Installation of Tracer Wire

Tracer wire, also called locating wire, is used to assist in locating underground non-metallic pipes. As the product pipes are laid, place the tracer wire immediately above the pipe. The wires are located using conduit and pipe locators to help the working crew to find the pipe during maintenance, repairs, or replacement. Tracer wire may be required for service pipe and laterals if
they are no metallic, it is highly recommended that tracer wire be a single segment running from
main tracer wire to curb box and be accessible from the top of the curb box.

The tracer wire runs along the length of the installed iPVC pipe. It shall be securely bonded
together at all wire joints with an approved watertight connector to provide electrical continuity,
and it shall be accessible at all tracer wire access points. Tracer wire access points shall be
accessible at all new water valve boxes, curb stop, water meter boxes, blow-offs, fire hydrants,
and access manholes. The tracer wire recommended is twelve (#12) gauge minimum solid copper
clad steel (CCS) or high strength copper clad steel (HS-CCD) with an average tensile break load
of 380#. 30-mil high molecular-high density polyethylene jacket complying with ASTM-D-1248,
30 volt rating. According to American Public Work Association (APWA), the uniform color code
for Potable Water coated tracer wire is blue (purple for raw water).

Following must be remembered while installing tracer wire:

- No connections shall be made in tracer wire for an individual service line
- Provide at least access points at the curb stop or meter pit
- Wrap all the exposed wire thoroughly with mastic type sealer specifically manufactured
  for underground use.
- Never wrap around fittings or valves
- The terminated wires must be capped using approved watertight cap.
- If the tracer wire is found to be not continuous after testing, it must be repaired or preferably
  replaced. At the end of pipe, allow sufficient length coiled and secured to the cap for
  future connections.
- Test the tracer wires for continuity; repair or replace the failed segment.
- The tracer wires must be terminated properly
- Do not allow the tracer wire to be placed between a tapping saddle and the iPVC pipe.

4.1.2.5 Backfilling and Compaction

After the placement of the pipes in the trench, the pipeline must be verified for alignment,
tested for pressure and leaks. The initial backfilling must be carried before the testing of the pipes
to prevent floating of the pipes. To achieve maximum compaction, it is recommended to compact
the backfill in layers. The compacted is continued until the standard proctor density of the soil is
achieved per the projects requirements. The final backfilling must follow immediately after testing
and achieving service connections and before placement of permanent surface. Figure 4.1 is typical
open-cut trench cross-section of iPVC pipe.

Following are to be verified before placing new iPVC pipe:

- Achieve required compaction rate before the final backfilling
- Use appropriate backfilling material and avoid pointed rock or any sharp edge material
  including debris in the backfill material
- Special backfill is used up to the top of most PVC pipe installations. iPVC is a stronger
  material and may not require such backfill. Further information on the use of native
  soils is discussed at the end of this manual
- Verify the tightness of the pipe and service connections for leaks
- The final backfill must be carried after the pipes are cooled during summer installation.
- Install the pipe below the frost line.
4.1.3 Installation in Contaminated Soils

The iPVC pipe does not corrode, rust, or degrade; mostly making it an inert pipe material for water application but the iPVC pipe may be subject to permeation with hydrocarbons, and petroleum products if found in high concentrations in the soil. The Water Research Foundation’s studies provide evidence that PVC pipes are impervious to most but not all hydrocarbons that are found in the soil. However, there is risk that some selected contaminants like toluene can put PVC pipe at risk. If contaminated soil is encountered or suspected during installation, it is suggested that the work be stopped and the soil tested.

4.1.4 Field Tasks

4.1.4.1 Cutting or Trimming

The iPVC pipes must be trimmed or cut using power tools such as handsaw or power driven abrasive disc only. Due to safety concerns, chainsaws are not recommended to trim the iPVC pipes. To obtain perfect square cut mark the pipe to be cut prior cutting or trimming. Use a beveling tool to bevel the trimmed end per the factory finished pipes. Measure and draw an insertion limit line on the new spigot end using factory marked spigot end as guide (Uni-Bell, 2016). Use appropriate PVC cutting tool to trim the pipe (see Figure 4.2).
4.1.4.2 Lubrication

Inspect the gasket for damage, clean the bell end (including gasket) and spigot end to remove any dirt or foreign matter. Apply lubrication to the gasket (surface in contact with spigot end) and bevel of the spigot end and approximately midway back to the insertion line on the spigot end evenly. Use lubrication provided by the manufacturer only. If the gasket is damaged and the gaskets are removable, replace it with new gasket. If gaskets are not removable, cut the bell and achieve the pipe connection using appropriate. Figure 4.3 presents surface preparation of bell and spigot ends and applying lubrication to the pipe after surface preparation.
4.1.4.3 Joining

Immediately after lubrication, the spigot end should be brought in contact with the bell end of the pipe. Both spigot and bell end should be aligned properly and then the spigot end of the pipe is slide inside the bell end until the reference marking provided by the manufacturer (see Figure 4.4). Do not drag or lay the pipe on the ground after lubrication.

Source: Courtesy of American Water.

Figure 4.4 Insertion reference marking on the spigot end of the pipe

iPVC pipes can be joined either manually or mechanically. In the manual method, the installer is able to control the amount of thrust being used to home the bell and spigot ends of pipe (see Figure 4.4B). When mechanical devices are used, it is very important to ensure the spigot ends are not over-inserted into the pipe bell (see Figure 4.4A).

To minimize stress on pipe, the pipes can be aligned straight with sufficient thrust to push the pipe until the reference marking on the bell is flush with the bell or fitting joint. A pipe that is misaligned, over-inserted, or assembled with excessive force can have consequences: rolled gasket, split bell, failure to pass acceptance testing and over-insertion of previous assembly joints.
TAPPING FOR SERVICE CONNECTIONS

The main line is tapped and service connected to the iPVC pipe, using mechanical connection and a saddle clamp. The service line is drawn from main until the curb stop and joined to the curb valve using mechanical joining techniques. A tracer wire is extended from the main to the curb stop to locate the service line in case of repair/replacement.

The iPVC pipes are no different from conventional PVC pipe with respect to tapping. The iPVC pipes are to be tapped using appropriate saddle (see Figure 4.6) and tapping tools (see Figure...
The tapping on the main line can be either 45 degrees or 90 degrees or straight line. It is recommended to use service saddle for small diameter tapping (2 inch and below) and tapping sleeves for tapping diameter size 2 inches and above. For further information on the tapping please refer to AWWA M23 Manual, Uni-Bell PVC Pressure Pipe Tapping Guide (Uni-Bell, 2016), AWWA C900, Uni-Bell’s *Handbook of PVC Pipe and Design and Construction* (Uni-Bell, 2012) or request your designer for more details.

**Source:** Courtesy of American Water.

**Figure 4.6 Appropriate saddle for proper connection**

**Source:** Courtesy of American Water.

**Figure 4.7 Tapping machine with feed nut and yoke**

### 4.3 SUMMARY OF INSTALLATION GUIDELINES FOR IPVC PIPE

As noted above the installer must evaluate the engineering documents provided for detailed construction information of the pipe. The following listed are general guidelines for the installation of pipe:
• The engineer must study the existing site conditions, the subsurface conditions, and determine if there are any utility lines are in conflict and requires any rerouting of the utility lines prior to the job.
• The pipe should be placed below the maximum frost line for frost protection
• Minimum depth of cover must be provided for loading condition if there is no frost line or follow the design drawings and specification for more details
• Size of the backfill materials must be free from debris and sharp objects that may damage the pipe.
• Initial backfill is applied as soon as possible to avoid floating of the pipe and final backfilling is must be done after flushing, testing, disinfecting, and verifying the tracer wire conductivity.
• Clean the bell and spigot (square cut and chamfered) before applying lubricant. Avoid over insertion of the pipe.
• Provide restrain and thrust blocks at the bends, valves, reducers, hydrants, and blow offs
• Test for leaks and pressure is recommended
• Tracer wire must be installed and terminated properly. The connections must be checked for continuity and conductivity
• Use appropriate tapping tools for service connections. Use a tapping saddle for 2 inch and smaller pipe size and tapping sleeve for greater than 2-inch pipe size.
CHAPTER 5
COMMISSIONING

5.1 INITIAL PIPE TESTING

The pipes are required initial backfill and achieve recommended compaction prior testing and paving the road. If the restrain joints are casted using Portland cement, sufficient time must be allowed to attain the strength of casted thrust block at the restrain joints before testing the pipe for tightness. The pipes are filled with water and tested to verify the proper installation and joining techniques (AWWA, 2002). This may help the installer to access the pipeline integrity before the successive testing on the pipe.

5.2 FLUSHING

The pipe must be clean and free from foreign particles after installation. It is required to flush the pipe before it is tested for leaking and pressure and subsequently activated for service. Foreign particles can damage valve or other fittings that could be a potential health hazard or damage the valves. The water in the pipeline is filled slowly with potable water and the flow in the new pipeline is recommended to maintain a velocity of 3 feet per second or higher. The duration of flushing is continued until the water in the line is clear and absent from entrapped air.

5.3 FILLING

The water service is filled slowly with water before to its operation pressure to remove any entrapped air in the system. The maximum velocity of filling the main is one foot per second. The pipe must be filled completely with water, making sure entrapped air is removed (AWWA, 2002).

5.4 HYDROSTATIC TESTING AND LEAK TESTING

The tightness and integrity of the pipeline is tested during the hydrostatic and leakage testing. The hydrostatic test is performed to determine if the pipeline will hold pressure, an indication of proper assembly. This test may be combined with leakage test (water added to the pipe to sustain pressure) to test for adequate water tightness. Prior to testing the pipeline should be adequately anchored by placement of sufficient back-fill to arrest excessive pipe movement. Joints and fittings should be left exposed to inspect for leaks and for joint tightening if necessary. Pressure testing should only be conducted with potable water; compressed air or other gases are not permitted. It is important that the pipe is filled slowly, 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 iPVC pipe be pressure tested for a minimum of one hour at 120% - 150% of the maximum operating pressure. 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 (AWWA, 2002).
5.5 DISINFECTION

Disinfection of iPVC pipe should be carried out in accordance with ANSI/AWWA C951, Standard for Disinfecting Water Mains. The disinfection must be carried and sustained after initial test/cleaning and after completion of hydrostatic and leakage tests. Chlorine is generally applied as pipe is installed or added as a supplement per the standard. Chlorine level is an indicator of a bacteriological concern. If the chlorine residual in the main is sustained, then there are no impurities in the systems creating a chlorine demand. If the chlorine residual is reduced or absent, then it can be suspected that the water mains contains impurities. The disinfectant solution should never be left in iPVC pipe for extended periods and when removed by flushing must be properly disposed. Follow local guidelines to dispose high chlorine residual water safely as it may have an impact on local water streams and soils, flora and fauna.

At the end of the disinfection process, the pipes should be thoroughly flushed and the system recharged with potable water. To confirm that the pipe is bacteriologically safe, a water sample must be collected for a 24-hour bacteriological test. If the bacteriological testing results are acceptable, the system can be put into service. If the test yields unacceptable results, disinfection may be repeated and testing repeated until satisfactory results are obtained (AWWA M23, 2002).

Q 1  Is iPVC pipe safe for drinking water?

Yes, the iPVC pipes are NSF/ANSI 61 certified pipes for potable water applications, which are produced from ASTM 17454 PVC compounds. The pipes are manufactured per AWWA C900-07 and M23 Manual.

Q 2  What standard dimensions the iPVC pipes are manufactured?

Presently, the iPVC pipes are manufactured in sizes, 4, 6, 8, 10 and 12 inches with dimension ratios 25, 18 and 14.

Q 3  What is the length of the iPVC pipes?

The iPVC pipes are available in standard 18 and 20-foot lengths.

Q 4  What is the difference between iPVC and the PVC (C900) and PVCO (C909)?

There is no difference between in the PVC resin in iPVC and AWWA. PVCO pipes are lighter and thinner than iPVC pipe. However, the iPVC pipe exceeds AWWA C900 and AWWA C909 by 13% more in tensile test, 15% more modulus of elasticity, 32% stiffer and 37% more strength subjected to burst pressure testing. The iPVC pipe is more resilient and proved 12 times stronger than C900/C909 during impact test. PVCO is extremely ductile but more easily loses its shape under load.

Q 5  Are long-term effects of creep a concern for iPVC pipe?

All plastic pipes are subject to creep. Proper design, such as using the long-term modulus of the material where appropriate, accounts for creep effects.

Q 6  What colors are used for iPVC pipe?

The iPVC pipes are manufactured in blue color.

Q 7  Will ultraviolet rays adversely affect iPVC pipe?

The UV rays are not a concern for iPVC pipes if the pipes are exposed for shorter duration. However, prolonged exposure to direct sunlight may diminish the engineering properties and change the color of the exposed pipe side. A research study on this issue was conducted by the Uni-Bell PVC Pipe Association (Dallas, TX) to determine the effects of UV radiation on PVC pipes. The study was conducted at 12 locations across the United States on the PVC pipes for a period of two years continuously exposing the pipes directly to sunlight and tested the pipe to pass all the requirements of the new pipe. The results revealed that both the tensile strength and the modulus of elasticity remained virtually unchanged, while the impact strength remained well...
within the governing ASTM requirements. To avoid material pipe degradation due to UV rays, proper sun protection (opaque tarpaulin cover) is recommended to cover the pipes with adequate ventilation to avoid heat build-up. (Refer to Uni-Bell technical report UNI-TR-5: “The Effects of Ultraviolet Aging on PVC Pipe (2003).”)

Q 8 What is the life expectancy of iPVC pipe?

Many installations of PVC C900 pipe in water applications are already reaching 50 years of successful service in USA and over 75 years in Europe. Presently, the PVC pipe industry conservatively estimates a service life of 50-100 years. Since, the iPVC pipe is similar to conventional PVC C900 pipe with enhanced engineering properties; the pipe may be speculated to have an equivalent service life.

Q 9 What is the optimum water temperature for iPVC pipe?

iPVC pipe has been installed in temperatures below freezing and above 100 degrees. Of course, owing to the temperature that water freezes, the buried pipe should not be subjected to temperatures below freezing. (See Q13.)

Q 10 What is the thermal coefficient of iPVC pipe?

The thermal coefficient of iPVC is between \(6 \times 10^{-5} \text{ inch/inch/}°\text{F} - 7 \times 10^{-5} \text{ inch/inch/}°\text{F}\)

Q 11 Is iPVC pipe resistant to hydrocarbon? What happens if the pipe is installed in the affected area?

The process of hydrocarbon or solvents seeping into the pipe and thereby contaminating water is called permeation. The iPVC pipe offers resistance to most hydrocarbons, however the pipe is not recommended to install in the contaminated areas unless the nature and concentrations of the contaminants are known. Certain hydrocarbons can degrade and damage some gasket materials.

Q 12 How iPVC pipelines are located?

A tracer wire should be buried above or below the iPVC pipe at the time of installation to facilitate future location. If no tracer wire was installed, ground-penetrating radar or acoustical resonance may be used but the first choice is always tracer wire.

Q 13 Does water freeze in the iPVC pipeline, will it damage the pipe?

The water does not freeze inside the iPVC pipes as long the flow and pressure are maintained in the pipe.

Q 14 Is it possible to damage and repair iPVC pipe?

Though substantially stronger than conventional PVC pipe, iPVC pipes can be damaged by stresses induced from improper installation, damage during excavation etc., If the damage is small (as in a pinhole), the pipe can be repaired by replacing appropriate damaged iPVC pipe.
section with the new iPVC pipe of same size and pressure class.

Q 15  What is an appropriate method for leak detection in iPVC pipe?

Acoustic techniques can be used to detect leaks in iPVC pipe if the equipment operates at subsonic frequencies that are typical of plastic pipe leaks. Leak noise does not travel as far in plastic pipe as it does in metallic pipe.

Q 16  Can iPVC pipe be used in trenchless application?

Presently, the iPVC pipe is not certified for trenchless application. In near future, iPVC pipe may be considered for trenchless application.

Q 17  Can iPVC pipe be tapped directly?

No, the iPVC pipe should not be tapped directly. Use appropriate saddle and tapping equipment (with feed nut and yoke) recommended for PVC pipes are used to tap the pipe. For more information about tapping, please use the highlighted link Uni-Bell.

Q 18  Can the iPVC pipe be tapped in a 45-degree angle and 90 degrees?

Yes, the iPVC tapping could be either 45 degrees or 90 degrees.

Q 19  What is the minimum (tapping) distance for service connection to service connection?

The iPVC pipe is recommended to be tapped at a distance of 3 feet or greater from the closest service connections.

Q 20  How iPVC pipes are joined? Does pipe require special lubricant?

The iPVC pipes are connected by simple bell and spigot homing. A marking is provided to prevent over insertion. The pipe does not require special lubricant, the conventional C900 PVC pipe lubricant can be used to achieve iPVC connections.

Q 21  Are iPVC pipes dimensions different from the conventional PVC?

No, the iPVC pipes are manufactured to comply AWWA C900.

Q 22  Do iPVC pipe require special cutting or trimming tool?

No, the iPVC pipe is no different from PVC; it can be cut or be beveled using the conventional hand or power tools.

Q 23  Is there any guide to tracing iPVC pipe? Is there a depth limit on the wire?

Assuming the tracer wires are run along the length of iPVC pipe and properly connected, the pipe via tracer wire can be easily located using customary metallic pipe locaters. For best
results, the locater unit should be used in conductive mode and connected to the tracer wire at one of the access points. As with metal pipe, the locater can be operated in inductive mode if the sending unit is directly over the tracer wire (results will not be as good). Tracer wire is highly conductive so the normal settings (usually up to about ten feet) will work with a conventional pipe locater. It is important to remember when depth readings are provided by the locater they refer to the depth of the wire and not necessarily the pipe. (Metallic piping depth readings provide centerline of pipe.)

Q 24 Can iPVC pipes be recycled?
Yes, the iPVC pipes can be recycled.

Q 25 Can iPVC pipes be used for raw water purposes?
Yes, the iPVC pipes are recommended to use for raw water pipes.

Q 26 Can iPVC pipes be used in hydrant laterals?
Yes, iPVC pipes can be used in hydrant lateral.

Q 27 How does iPVC pipe fails?
The iPVC has shown resilience under high pressures, cycling surges and impact. Hydrostatic burst tests performed on The Water Research Foundation project suggest that the pipe has strength in all directions. Some testing suggests that the pipe will expand rather than fracture. Most significantly, it does not appear that the pipe will crack longitudinally as is the case with conventional PVC pipe.

Q 28 Is the iPVC pipe design is different from PVC design?
No, iPVC pipe is not different from conventional PVC pipe in terms of layout and the pipe. It does have more resistance to load and in many circumstances, special backfill may not be required.

Q 29 What is coefficient of flow constant of iPVC pipe
The iPVC pipe has coefficient flow constant $C = 150$

Q 30 Do iPVC pipe allow bending or joint deflection during pipe installation?
The iPVC pipe prescribes no bending or deflection. Joint deflection or bending may be achieved using appropriate bends, sweeps or other fittings.
APPENDIX B
CHECKLIST

For any repair work or new installation of iPVC pipe, the following potential hazards of the operation, materials, equipment, and environment should be addressed before work begins, and plans should be made to minimize these hazards.

- Consider safety measures for the labor, material, and equipment from project inception to completion.
- Notice the residents, provide proper signs, barricade and traffic control signs in the construction area and its vicinity
- Use appropriate machine and slings for unloading the pipe
- Treat electrical tools as potential sources of ignition and follow standard safety procedures for working in explosive atmospheres.
- Only properly trained and qualified personnel should operate equipment.
- Wear suitable gloves, hardhat, safety boots and eye protection (personal protection equipment).
- While cutting the pipe, avoid standing close to the cutter and avoid wearing loose clothing. Avoid cutting the pipes inside the narrow trench.
- If spigot end is trimmed, always chamfer the new spigot end before making connection into the bell.
- Provide appropriate trench support to avoid collapsing of trench during installation. Place ladder always while working in the trench for quick egress.
- Clean the spigot and bell including gasket. Apply proper lubricant, align the pipe straight and join them with appropriate thrust. Do not over-insert the bell.
- Use appropriate saddles/sleeves and tapping tools while making live tapping for service connection. Using inappropriate tapping tool can create excess pressure on the PVC pipe, damage the pipe and may propagate crack that may lead to pipe failure.
- Use protective blanket while live tapping the main
- The tracer wires must be verified for continuity and must be terminated properly. The tracer wire must not be wrapped around pipe or pipe fittings.
REFERENCES


<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANSI</td>
<td>American National Standards Institute</td>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Material</td>
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<td>AWWA</td>
<td>American Water Works Association</td>
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<tr>
<td>CTS</td>
<td>Copper Tube Sizes</td>
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<tr>
<td>DIS</td>
<td>Ductile Iron Sizes</td>
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<td>Dimension Ratio</td>
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<td>High Density Polyethylene/ Polyethylene</td>
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<td>PPI PVC pipe product</td>
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