Installation Handbook: CPVC Hot & Cold Water Piping

Introduction

Chlorinated polyvinyl chloride (CPVC) pipe, tube, and fittings have been successfully used in hot and cold water distribution systems since 1960. From 1960 through 2000, enough CPVC tubing was sold to plumb millions of typical, single-family dwelling units and usage is increasing each year.

The product consists of SDR 11 CPVC tube made to the Copper Tube Size (CTS) ODs (outside diameters), and CPVC socket-type fittings. The standard covers sizes ½-inch through 2-inch and both the tube and fittings are tan in color. As hot and cold water piping, the system carries a continuous use rating of 100 psi at 180° F and 400 psi at 73° F. When sizes larger than 2-inch are needed, Sch. 80 CPVC pipe (ASTM F 441) made to iron pipe size (IPS) ODs (outside diameters), and Sch. 80 CPVC fittings (ASTM F 437 and F 439) are used. Some codes require proof testing of assemblies for 48 hours at 150 psi/210° F. Most producers have had these tests performed to qualify their products for use under such codes. CPVC CTS tube and CPVC IPS Sch 80 pipe are sold in straight lengths. Smaller diameter CTS tube is also sold in coils.

General Information

This handbook is intended to provide basic information for the installation of CPVC (Chlorinated PolyVinyl Chloride) piping[1] for hot and cold water distribution systems and is published for the benefit of installers, contractors, code officials, distributors, and home owners. The information has been presented as simply and concisely as possible, but the reader should be aware that more detailed information is available from the manufacturer of your CPVC piping or from the supplier of the raw material used in the piping. Some subjects in this handbook are interrelated and may be discussed in more than one section. The authors strongly recommend reading the entire handbook, so the user will be familiar with all aspects of the interrelated items.

The statements and descriptions in this handbook are informational only and are not intended as an endorsement or warranty with respect to any product or system. The Plastic Pipe and Fittings Association (PPFA) and its members make no warranties or representations 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 in actual construction.

In all cases, the appropriate local authorities should be consulted concerning the requirements covering the use of any particular product or system in any specific application. The manufacturer's label and/or instructions should also be followed. General questions on piping system design or installation described herein may be directed to the Plastic Pipe and Fittings Association.

1 The term piping covers pipe, tube, and fittings, and the terms pipe and tube are used interchangeably.

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How to Identify the Product

In order to comply with the standard, CPVC tube shall have the following information printed on it: (a) manufacturer's name, (b) certification or listing agency mark (e.g. NSF-PW or other acceptable agency's mark), (c) size, (d) ASTM D 2846 CPVC 4120, (e) SDR 11, (f) 100 psi @ 180° F.

In order to comply with the standard, CPVC pipe shall have the following information printed on it: (a) manufacturer's name, (b) certification or listing agency mark, (c) ASTM standard number F 441, (d) size, (e) Sch. 80, (f) pressure rating.

In order to comply with the standard, CPVC fittings shall have molded markings of (a) manufacturer's name, (b) certification or listing agency mark, (c) ASTM standard number (D 2846 or F 439), (d) material designation (CPVC 4120 or CPVC for CPVC 23447).

In order to comply with the standard, CPVC solvent cement shall have on the label (a) CPVC Solvent Cement, (b) ASTM F 493, (c) certification or listing agency mark, (d) manufacturer's name and address.

In order to comply with the standard, primer shall have on the label (a) primer, (b) ASTM F 656 (c) certification or listing agency mark, (d) manufacturer's name and address.

The following standards apply to CPVC and related products:

- ASTM D 2846 — Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Hot and Cold Water Distribution Systems;
- ASTM F 493 — Standard Specification for Solvent Cements for CPVC Pipe and Fittings;
- ASTM F 656 – Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride)(PVC) Plastic Pipe and Fittings;
- ANSI/NSF Standard 14 — Plastic Piping Components and Related Materials;
- ANSI/NSF Standard 61 — Drinking Water System Components — Health Effects; and
- ASTM F 402 — Standard Practice for Safe Handling of Solvent Cements, Primers and Cleaners* for Joining Thermoplastic Pipe and Fittings.

** Cleaner, chemical – an organic solvent used to remove foreign matter from the surface of plastic pipe or fittings.*

Product that does not have legible marking or has a marking that does not contain all pertinent information may not conform with the applicable standard.

Verify local code approval before installing CPVC piping.

CPVC piping is included in both the International Plumbing Code (Boca, SBCCI, and ICBO) and the Uniform Plumbing Code (IAPMO); plus the CABO One & Two Family Dwelling Code, the National Standard Plumbing Code (NAPHCC) and FHA/HUD Use of Materials Bulletins. State and local government/agencies can adopt these model codes as published or modify them.

Therefore, among the questions to be asked are the following:

Is a model code being used?

If so, which one, and have any modifications been made in regard to CPVC piping?

Basics

Since most of the system design parameters, e.g. minimum pressure, fixture unit or flow sizing of pipe, and limiting velocity, are prescribed in the applicable plumbing code and in ASTM D 2846, CPVC tube is usually used as a direct size-for-size replacement for copper tube. However, because CPVC is a thermoplastic rather than a metal, there are certain differences in handling, cutting, joining, and installation, and these are detailed here.

Identification & Storage

CTS Tube: Check the markings to make sure it is ASTM D 2846 SDR 11 CPVC; IPS Pipe: Markings must be ASTM F 441 Schedule 80 CPVC. All pipe or tube must have a listing agency mark. Look at the pipe to make sure there are no signs of damage or cracked ends. Store straight lengths of pipe flat with full-length support. Cover or store indoors.

Fittings: Check for marking on bag (or box) and on fittings. Store indoors.

Solvent cement, primer and cleaner: Check for markings on cans and store indoors.

Cutting & Chamfering

CPVC pipe is easy to cut with a tubing cutter (photo A), a power saw, handsaw, or a ratchet cutter. When using a ratchet cutter, blades should be sharpened regularly. The tubing cutter should be equipped with a blade made especially for cutting plastic. A roller-type tubing cutter with a cutting blade designed for metal is not satisfactory, even if the blade is new. All cuts should be made so they are square to the tubing.

Chamfer the end of the pipe (photo B) and remove any burrs. Although this can be done with a knife or file, a chamfering tool that produces a 10° to 15° chamfer is ideal. **Use a clean, dry rag**; wipe dirt and moisture from the fitting sockets and tubing ends.

A

B

C

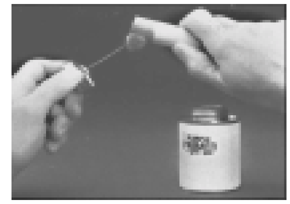
Check Dry Fit

This is done just before a joint is solvent cemented, and it verifies the pipe OD and the fitting socket tolerances (photo C). The pipe should go into the socket 1/3 to 2/3 of the socket depth before it makes contact with the socket wall. This interference is necessary and provides a joint that will quickly attain the desired handling strength and give good, long-term service.

Primer & Cement

CPVC piping and fittings are joined with CPVC cements. The solvent cement process can be a one- or a two-step process. The one-step cement does not require the use of a primer; the cement will be yellow in color. The two-step process does require the use of a primer; the cement will be orange in color. Both types of cements are manufactured under ASTM F 493 for use with CPVC hot and cold water piping (½-inch to 2-inch sizes) that conform with ASTM D 2846. The label on the can will indicate the cement color and whether a primer is required. Before using one-step cement, check to determine if the local code permits its use or if two-step cement with primer is required.

If primer is required, apply it to the outer surface of the pipe end (photo D) and the inner surface of the fitting socket (photo E) using a dauber supplied in the can or a brush which is at least one half the size of the pipe (½-inch min.) but not larger than the size of the pipe.



D

E

Apply a light coat of CPVC cement to the socket contact surface (photo F) and a full layer to the pipe end contact surface (photo G). Immediately insert the pipe into the socket and bottom it with a ¼ turn (photo H). Hold the pipe in the socket firmly for 10 to 15 seconds. When released, the pipe should not “push out” of the socket. If “push out” occurs, increase the “holding in” time. If the surface dries before the joint is put together, quickly apply another light coat of cement to the pipe end and then assemble.

F

G

H

Do not use excessive amounts of primers or cements or allow them to puddle in the socket.

A good job of cementing is evidenced by an even bead or filet of cement all around the pipe at the socket interface. Wipe off any excess cement. At temperatures below 40º F, extended cure cycles may be required. Consult the solvent cement manufacturer’s specifications for guidelines. In extremely hot temperatures, above 100º F, make sure both surfaces to be joined are still wet with cement when putting them together.

Solvent set and cure times are a function of pipe size, temperature, and relative humidity. Curing time is shorter for drier environments, smaller sizes, and higher temperatures. Follow the solvent cement manufacturer’s recommended drying times. On smaller sizes and with short pieces of pipe, the joint has adequate handling strength almost immediately so that assembly can proceed without delay.

Safe Handling of Primer, Cleaner & Cement

Solvent cements, primers and cleaners must be handled properly. To do so, refer to ASTM F 402, Standard Practice for Safe Handling of Solvent Cements, Primers and Cleaners, which contains the following directions:

"Avoid prolonged breathing of solvent vapors. When pipe and fittings are being joined in partially enclosed areas, use a ventilating device in such a manner as to maintain a safe level of vapor concentration with respect to toxicity and flammability in the breathing area. Select ventilating devices and locate them so as not to provide a source of ignition to flammable vapor mixtures.

"Keep cements, primers and cleaners away from all sources of ignition, heat, sparks and open flame.

"Keep containers of cements, primers and cleaners tightly closed except when the product is being used. The container type shall be in accordance with Parts 1 to 199, Title 49 — Transportation, Code of Federal Regulations. Container labeling shall conform with the requirements of the Federal Hazardous Substance Act and OSHA Hazard Communication Act.

"Dispose of all rags and other materials used for mopping up spills in an outdoor safety waste receptacle. Empty the receptacle daily with proper consideration for its flammable hazard.

"Most of the solvents used in pipe cements, primers and cleaners can be considered eye irritants and contact with the eye should be avoided as it may cause eye injury. Proper eye protection and the use of chemical goggles or face shields are advisable where the possibility of splashing exists in handling these products. In case of eye contact, flush with plenty of water for 15 minutes and call a physician immediately.

"Avoid contact with the skin. Wear proper gloves impervious to and unaffected by the solvents when contact with the skin is likely. Application of the primers, cleaners, or solvent cements with rags and bare hands is not recommended. Brushes, daubers, and other suitable applicators can be used effectively for applying these products, thus avoiding skin contact. Dispose of used applicators in the same manner as the rags. In the event of contact, remove contaminated clothing immediately and wash skin with soap and water. Wash contaminated clothing before wearing them again."

Expansion & Contraction

CPVC pipe, like all other piping, expands when heated and contracts when cooled. A 100-foot run of CPVC piping will expand about 4 inches with every 100°F-temperature increase. Expansion does not vary with size. Measured expansion of installed piping is typically well below the theoretical values. Although some expansion joints are available, they are hardly ever used in water distribution systems. Thermal expansion in CPVC systems is usually accommodated at changes in direction or by offsets as shown below in the table. Full expansion loops are the least common of the three arrangements shown.

Example: Pipe Size - $^1/_2$"
Length of Run - 60'
L = 38" (From Table)

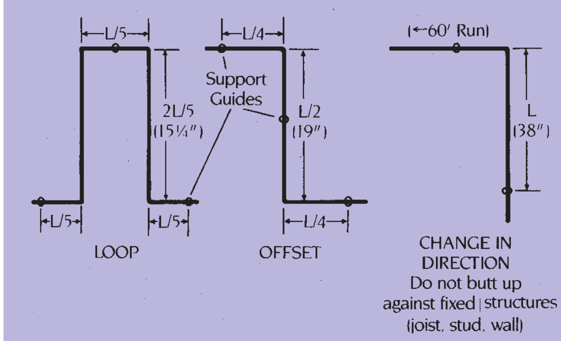


Table 1: Loop Length (inches)

Run length (ft)		20	40	60	80	100
Nom.Size	Avg. OD	Loop length "L" in inches				
½"	0.625	22	31	38	44	50
¾"	0.875	26	37	46	52	58
1"	1.125	30	42	52	60	67
1¼"	1.375	33	47	57	66	74
1½"	1.625	36	51	62	72	80
2"	2.125	41	58	71	82	91

Supports

Vertical piping should be supported at each floor level or as required by expansion/contraction design. Provide mid-story guides.

Point support must not be used for thermoplastic piping, and in general the wider the bearing surface of the support, the better. Supports should not be clamped in a way that restrains the axial movement of pipe that will normally occur due to thermal expansion and contraction. Concentrated loads, such as valves, must be separately supported.

Where pipes go through wood studs, provide oversize holes to allow pipe to move. When installed through metal studs, provide grommets or some form of insulation to protect the pipe from abrasion and to prevent noise.

Support Spacing

For horizontal spacing, Table 2 (below) shows the maximum spacing of supports based on hot water applications.

Table 2: Maximum Support Spacing

Nominal size	Max. spacing of supports
½” & ¾	36”
1”	40”
1¼”	46”
1½”	52”
2”	58”

Table 3: Support Spacing (per codes)

Nominal size	Support spacing
1” or smaller	3 ft
1¼ or larger	4 ft

Although incremental variations are technically correct, most codes use the simplified version shown in Table 3 (above).

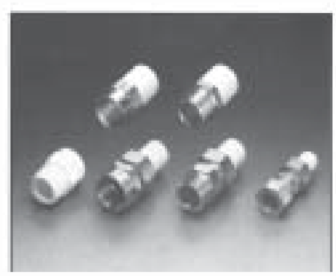
Transition Joints & Fittings

Special transition fittings or joints are used whenever CPVC piping is connected to a metal valve, fitting, or other appurtenance such as a filter, or to parts made of another plastic. These special transition fittings can have many forms (photo I). One common form is the true union with a metal end and a CPVC end held together with a plastic or metal gland nut and having an elastomeric seal between them. Other forms are the flanged joint, the grooved joint, insert molded metal in CPVC fittings, patented push-on type fittings, and finally the CPVC female threaded adapter with an elastomeric seal at the bottom of the thread. The latter fittings are designed so that they have no thread interference and rely entirely on the elastomeric seal for water tightness. They require only minimal torque to attain an adequate seal.

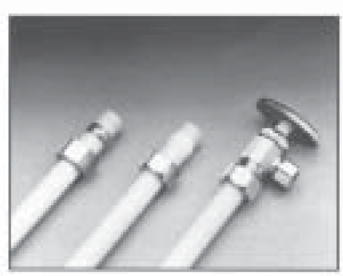
Standard compression fittings that utilize brass or plastic ferrules can be used to assemble CPVC (photo J). However, Teflon® tape should be applied over the brass ferrule to compensate for the dissimilar thermal expansion rates of the brass and CPVC that could possibly otherwise result in a drip leak. Care should be taken not to over-torque the compression connection.

Metal fittings with CPVC socket inserts are also available. The tubing is cemented directly into the socket in the same way as an all-CPVC fitting.

The standard practice is to thread a male thread adapter into the female threaded part, such as a valve or stop, and then solvent cement to the CPVC pipe. However, when using the male thread adapter, there are two limitations that the installer must consider when deciding where and how to use it. First, the male thread adapter may develop a drip leak if the joint is subjected to too broad a temperature range. And second, some thread sealants intended to minimize leak problems may chemically attack the CPVC and cause stress cracking of the adapter (see Thread Sealants section). The preferred method of transitioning between metal and CPVC plumbing components is to use an insert molded metal-in-CPVC fitting or true union with a metal and a CPVC end.



I



J

Female threaded CPVC adapters without an elastomeric seal should never be used.

If a tapered pipe thread connection between the CPVC and metal components must be made, use a CPVC male thread adapter. Consult the fittings manufacturer for additional limitations.

Thread Sealants

Threaded CPVC fittings with tapered pipe threads (e.g. male thread adapters) must be used with a suitable thread sealant to insure leak-proof joints. Over the years, PTFE (Teflon® or equivalent) tape has been the preferred thread sealant and it is still the most widely accepted and approved sealant.

Some paste sealants can affect CPVC fittings; therefore only sealants recommended for use with CPVC by the thread sealant manufacturer should be used.

Water Heater Connections

Some plumbing codes contain detailed requirements for connections to gas or electric storage type water heaters. Determine whether your code has such requirements and satisfy them.

If no detailed requirements exist, use the following information. On electric water heaters CPVC can be piped directly to the heater with special metal-to-CPVC transition fittings (photo L). On high-efficiency, gas water heaters that use plastic vent piping, CPVC can be connected directly to the heater just like the electric water heater connections (photo L). On all other gas water heaters there should be at least 6 inches of clearance between the exhaust flue and any CPVC piping (photo K). Twelve-inch long metal nipples or appliance connectors should be connected directly to the heater so that the CPVC tubing cannot be damaged by the build-up of excessive radiant heat from the flue.

An approved temperature/pressure (T/P) relief valve should be installed so that the probe or sensing element is in the water at the top of the heater. CPVC is approved by all the model codes for use as relief valve drain line piping. Use a metal-to-CPVC transition fitting to connect to the relief valve and continue the pipe full size to the outlet. For horizontal runs, slope the pipe toward the outlet and support it at three-foot centers or closer. The pipe must discharge to the atmosphere at an approved location.

K

L

While CPVC piping systems are suitable for use with properly controlled residential tankless water heaters, do not use CPVC pipe and fittings with commerical-type, non-storage water heaters.

Pressure Testing (Joint Cure Time)

When pressure testing CPVC piping, the focus is on time required for the solvent-cemented joints to gain sufficient strength to permit pressure testing without affecting the long-term strength and durability of the system. ASTM D 2846 contains pipe OD and socket ID tolerance requirements that are more restrictive than those in most other pressure piping standards. Because of this, the solvent-cemented joints gain strength very quickly after assembly.

Furthermore, it is widely recognized that pipe size is also a factor in the joint setting and curing process.

Joint setting time refers to the time required for the solvent-cement joint to reach handling strength.

While the joint set times are rarely measured or reported, workers very quickly recognize them as being a function of pipe size, temperature, degree of interference, and even length of the pipes being handled.

The joint cure time is the time required before a system containing newly cemented joints can be pressure tested and/or put into service. While minimum joint cure times are usually not a factor in new installations, they may be a factor in repair jobs or minor revisions to piping. The following Table and text taken from ASTM D 2846 Appendix X deal with this subject.

X2.3.3 Pressure Testing — CPVC piping systems made of ½-inch through 2-inch sizes per ASTM D 2846 can be pressure tested (using cold tap water only) at line pressure (150 psi max.) after the solvent cement joints have cured for at least the following amount of time:

Table 4: Minimum Cure Times

Ambient temperature	Pipe sizes ½" to 1"	Pipe sizes 1¼" to 2"
Over 60°F	1 hr.	2 hr.
40-60° F	2 hr.	4 hr.
Below 40° F	4 hr.	8 hr.

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Consult solvent cement manufacturers' installation instructions for more detailed cure times.

CPVC must not be used for piping systems intended to convey air or other compressed gases and should not be tested with air or other compressed gases.

Insulation lubricants may cause severe stress cracking of CPVC fittings. Only non-lubricated insulation products (rubber or polyolefin) should be used with CPVC systems.

Thermal Conductivity, Condensation & Sweating

In general, plastic materials have low coefficients of thermal conductivity when compared with metallic materials (see table below). Because of this, some people ask whether insulation is necessary to prevent heat loss from hot water piping or sweating of cold water piping. Generally, it is not necessary to insulate CPVC piping within heated buildings. Following are some factors to support this:

- 2" Sch. 80 CPVC pipe (2.375" OD - 0.230" wall) would lose about 140 BTU/h/LF while conveying 170° F water in a 70° F air environment.
- 2" Type M copper tube (2.125" OD - 0.060" wall) would lose about 5,000 BTU/h/LF under the same conditions.
- However, both the CPVC and the copper pipe will cool to ambient temperature in a short time when there is no flow.
- CPVC piping carrying 180° F water will have an outside surface temperature of about 150° F in an air-conditioned building.
- Under most use conditions that cause copper tube to sweat and drip, CPVC will remain free of condensation.

Thermal conduction is defined as "transfer of heat from one part of a body to another part of the same body, or from one body to another in physical contact with it, without appreciable displacement of the particles of the body." This definition leads us to the commonly used "K" factor, which refers to thermal conductivity.

Table 5: Typical "K" Factors

Material	BTU/h/SF/°F/ft	BTU/h/SF/°F/in
Copper	218.0	2616.0
Cast Iron	26.8 to 30.0	321.6 to 360.0
Steel	26.0	312.0
Concrete	0.54	6.5
Brick	0.4	4.8
PEX	0.21	2.5
Wood	0.06 to 0.12	0.7 to 1.4
PVC	0.11	1.3
CPVC	0.08	1.0

Freezing & Thawing

One of the most common conditions that can stop the function of the water distribution system is freezing. While this condition immediately stops the flow of water at the fixture, it may or may not have progressed to the point of rupturing the pipe. Therefore, immediate steps should be taken to locate the frozen section and alleviate the problem. As soon as the frozen section is located, close any outside openings with insulation, circulate warm air into the area, or direct heated air onto the piping. Limit the heat source to 180° F or less. If the frozen section is substantially inaccessible, it may be possible to cut open the line at an accessible point and insert a small flexible tube and pump hot water directly to the ice plug. As the hot water is pumped in and the ice is melted, the excess flows back out around the flexible tube.

Once the ice plug has melted, check to see if any pipe or fitting is ruptured, make repairs if necessary, and insulate the area or pipe to prevent future freezing. **Do not use an open flame to heat the frozen pipe.**

Hydraulic Shock (Water Hammer)

Although the peak surge pressure that results from interrupting flow in a CPVC pipe is smaller than the pressure in metal pipe, when the velocity is the same, both can produce "hydraulic shock." While some codes prescribe the use of accessible water hammer arresters adjacent to each solenoid operated valve, other codes do not speak to the

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subject and leave the decision up to the designer or installer. Water hammer arresters or air chambers are recommended when line pressure is high or where there are high flow fixtures with solenoid valves.

Grounding

Because CPVC is electrically non-conductive, it cannot be used as an electrical ground, and care must be taken to provide a suitable ground whenever CPVC piping is installed to replace metal piping that has been used as a ground. Because plastic water service lines are being used extensively, and because of galvanic corrosion to metal piping systems from ground faults, many codes prohibit grounding to any type of hot and cold water pipe. Check your local code.

Fire Rated Construction

CPVC water piping can be used within fire rated buildings provided all penetrations of fire barriers (e.g. walls or floor slabs) are made in such a way that the fire rating of the barrier will not be compromised. Most codes and code officials accept penetration sealing systems or devices that have qualified for UL Certification and Listing or have passed appropriate ASTM E 119 or E 814 tests. The PPFA manual *Plastic Pipe in Fire Resistive Construction* provides more detailed information on this subject and lists available test reports. (Or see the current issue of the Underwriters Laboratories, Inc. Directories of Fire Resistance - Vol. II or WHI Certification Listings.)

Underslab Installations

CPVC is approved for underslab installations, with joints, in all model plumbing codes.

When performing underslab installations, it is important that the tube is evenly supported on a smooth bottom. The bedding and backfill should be sand or clean soil free of sharp rocks and other debris that could damage the tube. Systems with joints under slab must be pressure-tested* before pouring the slab. The tube should be sleeved where it penetrates the slab and at construction joints in the slab.

CPVC water piping, manufactured in accordance with ASTM D 2846, is available in coils for underslab installations. When turning the end up through the slab, into walls, etc., be careful not to kink the pipe. Should a kink result, it must be cut out to avoid possible failure. Follow the pipe manufacturer's installation instructions for minimum bend radius permitted to be imposed on the coiled pipe.

CPVC in Plenums

CPVC plumbing pipe is safe for installation in return air plenums; however, the installation must be approved by the local jurisdiction. Even though CPVC is considered a combustible material, it will not burn without a significant external flame source. Once a flame source is removed, CPVC will not sustain combustion. Testing indicates that water filled CPVC in diameters 3-inches or less will pass the 25/50 flame smoke developed requirements for non-metallic material in return air plenums.

CPVC fire sprinkler pipe tested and listed in accordance with UL 1887, "Fire Test of Plastic Sprinkler Pipe for Flame and Smoke Characteristics," meets the requirements of NFPA 90A for installation in return air plenums.

The IAPMO IS 20 - 05 (Installation Standard for CPVC SOLVENT CEMENTED HOT AND COLD WATER DISTRIBUTION SYSTEMS) requires a pressure test for 2 hours. This requirement applies only to pipe installed under a slab.

PPFA Revision Policy

The PPFA CPVC Product Line Committee has initial responsibility for assuring that the data and other information in this handbook are current and accurate. All suggestions and recommendations for revisions to this handbook should be addressed to PPFA, 800 Roosevelt Road, Building C, Suite 312, Glen Ellyn, IL 60137, Attn.: CPVC Product Line Committee, and the Committee will respond to them as promptly as reasonably possible. The CPVC Committee will review and update the handbook as required based on comments or questions. A complete review will be made at least once every three years.