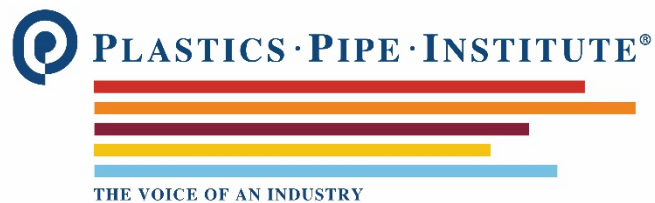


SUITABILITY AND FITNESS OF CPVC PIPING SYSTEMS FOR COMMERCIAL BUILDING APPLICATIONS

TN-62

2020



Foreword

This technical note was developed and published with the technical help and financial support of the members of the Plastics Pipe Institute (PPI). These members have shown their commitment to developing and improving quality products by assisting standards development organizations in the development of standards, and also by developing design aids and reports to help engineers, code officials, specifying groups, contractors and users.

The purpose of this technical note is to discuss the suitability and fitness of CPVC piping systems for commercial building applications.

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This Technical Note was first issued in January 2020.

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SUITABILITY AND FITNESS OF CPVC PIPING SYSTEMS FOR COMMERCIAL BUILDING APPLICATIONS

1.0 INTRODUCTION

CPVC is a high-temperature plastic pressure piping system introduced for potable plumbing applications in 1959. CPVC tubing comes in nominal sizes ranging from 1/2 to 2 inch copper tube size (CTS) in SDR 11 wall thickness. CPVC pipe is produced in nominal sizes ranging from 1/2 to 24 inch in Schedule 40 and 80 and several SDR (e.g. SDR 11, SDR 13.5) wall types, with iron pipe size (IPS) outside diameters.

Advantages of CPVC piping systems include:

- Safety of potable water and long-term reliability
- Resistance to corrosion, tuberculation, deposits
- Chlorine and chloramine resistance
- Lightweight, easy to transport
- Available in wide range of sizes
- Noise and water hammer resistance
- Minimal scrap value, avoiding jobsite theft
- Durability and toughness to survive jobsite installations
- No flame used for joining; solvent cement and/or mechanical joints
- Standardized pipe and fitting dimensions
- Professional installed appearance

CPVC tubing and pipe are sold in straight lengths for use with molded fittings. See **Figures 1 and 2**.



Figure 1: CPVC pipe



Figure 2: CPVC molded fittings

This Technical Note will explain material properties and capabilities that should be considered when designing CPVC systems for commercial building applications. The content in this document may be used to apply to applications such as hot- and cold-water distribution (potable water plumbing), fire protection, chilled water, and hydronic heating and cooling systems.

CPVC piping materials are also used in various process piping and industrial applications, which are outside the scope of this document.

Topics discussed in this document include:

- Section 2.0: CPVC Material Definition
- Section 3.0: Suitability for high-temperature applications
- Section 4.0: Effects of potable water disinfectants on CPVC piping materials
- Section 5.0: Mixed-material systems that contain both copper materials (i.e. tubing, fittings, valves) and CPVC
- Section 6.0: Other Design Issues

This Technical Note is not a design manual. Engineers, designers, and installers should refer to CPVC pipe, tubing and fitting manufacturer's technical data and design manuals for detailed design and installation information.

2.0 CPVC MATERIAL DEFINITION

CPVC is polyvinyl chloride (PVC) that has been chlorinated via a free radical chlorination reaction. CPVC material is produced by adding chlorine to PVC in a water slurry or fluidized bed chlorination process. The chlorination reaction is initiated by ultraviolet light. The chlorinated PVC is compounded with ingredients necessary for the desired properties for further processing.

The chlorine added to PVC gives CPVC higher temperature performance and improved fire and corrosion resistance. CPVC pressure pipe is a distinct material from PVC pressure pipe, with additional capabilities, and is accepted in all model plumbing and mechanical codes for applications such as hot- and cold-water distribution (potable water plumbing), fire protection, chilled water, and hydronic heating and cooling systems.

2.1. Product Standards

- ASTM D2846 *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot- and Cold-Water Distribution Systems*
- ASTM F441/F441M *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedule 40 and 80*
- ASTM F442/F442M *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*
- ASTM F437 *Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*
- ASTM F438 *Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*
- ASTM F439 *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*
- ASTM F493 *Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings*
- ASTM F1970 *Special Engineered Fittings, Appurtenances or Valves for use in Poly (Vinyl Chloride) (PVC) OR Chlorinated Poly (Vinyl Chloride) (CPVC) Systems*
- CSA B137.6 *CPVC Pipe, Tubing and Fittings for Hot and Cold Water Distribution Systems*
- NSF/ANSI 14 *Plastics Piping System Components and Related Materials*
- NSF/ANSI/CAN 61 *Drinking Water System Components – Health Effects*

3.0 CPVC SUITABILITY for HIGH TEMPERATURE APPLICATIONS

CPVC piping systems are pressure-rated for operation up to 200°F (93°C), according to the procedures found within the industry standards listed in Section 2.1. Actual pressure ratings depend upon wall type (e.g. SDR 11, SDR 13.5, Schedule 80) which dictates the actual wall thickness.

For SDR 11 CPVC tubing, standard hydrostatic pressure ratings are 400 psi at 73°F (2,750 kPa at 23°C) and 100 psi at 180°F (690 kPa at 82°C).

Note #1: Consult the specific CPVC pipe and fitting manufacturer's literature and listings, as well as the solvent cement manufacturer's literature and listings, for appropriate temperature and pressure ratings and limitations.

Years of experience, combined with long-term hydrostatic testing per ASTM Test Method D2837 *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*, and as listed in PPI TR-4 *Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), Minimum Required Strength (MRS) Ratings, and Categorized Required Strength (CRS) for Thermoplastic Piping Materials or Pipe*, have proven the resistance of CPVC to continuous operation at elevated temperatures such as found in hydronic heating systems and certain commercial plumbing systems.

For all thermoplastic piping products, operating pressures are dependent on the operating temperatures – the higher the temperature, the lower the pressure rating. As per ASTM F441/F441M and F442/F442M, *Temperature Derating Factors* as shown in **Table 1** for CPVC pipes conveying fluid at elevated temperatures must be applied.

Table 1: Temperature Derating Factors for CPVC pipe

Temperature		Pipe Derating Factor	
°F	°C	CPVC 4120-05 ¹	CPVC 4120-06 ¹
73 to 80	23 to 27	1.00	1.00
90	32	0.91	0.91
100	38	0.82	0.83
120	49	0.65	0.70
140	60	0.50	0.57
160	71	0.40	0.44
180	82	0.25	0.31
200	93	0.20	^A

^A Consult with specific product or component manufacturer for temperature derating factors above 180°F (82°C)

¹ See ASTM F441/F441M and F442/F442M for material descriptions and requirements related to pipe material designation codes CPVC 4120-05 and CPVC 4120-06.

To determine an elevated temperature rating, multiply the 73°F pressure rating by the derating factor from the appropriate column in **Table 1**.

Example: Per ASTM F442, SDR 11 CPVC Pipe is rated at 400 psi @ 73°F. Calculate the pressure rating for a pipe made from CPVC 4120-05 material at 160°F.

Answer: 400 psi x 0.40 = 160 psi at 160°F

Certain regulations and codes for domestic hot-water plumbing systems specify that the minimum hot-water temperature shall be 140°F (60°C), to prevent the potential growth of water pathogens such as legionella. This range of temperature is also found in many commercial plumbing systems. Rated for operation under pressure at temperatures up to 200°F (93°C), CPVC piping systems are suitable for such applications.

Importantly, the maximum temperature of water during a high-temperature disinfection process must not exceed the rating of the pipe or any piping components at the operating pressure of the building's plumbing system.

Refer to the CPVC pipe manufacturer's published ratings and product standards such as ASTM D2846, F441/F441M, F442/F442M, or CSA B137.6 for specific information about pressure ratings at various temperatures.

4.0 EFFECTS OF POTABLE WATER DISINFECTANTS ON CPVC

CPVC systems are immune from chlorine degradation and will not be affected by systems operating continuously at temperatures up to 200°F (93°C) even when used in conjunction with high levels of chlorine for disinfection purposes.

In some instances, such as the process of thermal disinfection of commercial plumbing systems, which may be intended to prevent or kill the growth of water pathogens such as legionella, plumbing systems may be exposed to water temperatures of 160°F (70°C) or higher, combined with high levels of disinfectants such as chlorine, chloramines, or chlorine dioxide for short periods of time. CPVC piping systems are suitable for such exposures.

Thanks to its smooth walls surfaces, CPVC pipes are also less likely to host the growth of biofilms, which can harbor bacteria as well as potential food sources for the bacteria.

5.0 MIXED-MATERIAL SYSTEMS THAT CONTAIN BOTH COPPER MATERIALS (I.E. TUBING, FITTINGS, VALVES) AND CPVC

Plumbing and mechanical codes adopted throughout Canada and USA contain requirements which limit the flow velocity through copper tubing and components, to help prevent various types of erosion and corrosion of the copper material. These requirements are often based on Copper Development Association guidelines, such as CDA Publication A4015-14/16: *The Copper Tube Handbook*.

When such limits are not adhered to, copper components can suffer from "flow-accelerated" or "flow-induced" corrosion. The speed and degree of such corrosion is dependent upon several factors, such as:

- The chemistry of the water (i.e. "aggressiveness")
- Water temperature
- Water velocity
- Cavitation where changes in flow direction occur.

When it occurs, this type of attack on the copper tubing components can release dissolved copper into the water. This effect has been reported in various regions of the world, including North America.

As published in PPI TN-57 *Proper Integration of Copper Tubing and Components with PP-R Piping Materials for Plumbing Applications*, “In certain circumstances, dissolved copper can greatly accelerate an oxidative reaction between the chlorine (added as a water disinfectant) or dissolved oxygen in the water, or both, and the PP-R piping material, degrading the PP-R material over time. The result can be premature failure of the PP-R piping components, especially in locations of external physical pressure, such as with high clamping force of brackets.”

CPVC is not susceptible to copper ion catalyzed oxidation degradation. Metal ions are not known to affect the oxidation stability of CPVC. Due to its chlorinated structure, CPVC has inherently good resistance to oxidizers. Further, due to its amorphous structure and high glass transition temperature, CPVC is resistant to oxidizers and metal ions.

6.0 OTHER DESIGN ISSUES

With all piping systems, proper design and installation is critical. Building codes, industry manuals, and the pipe and fitting manufacturers’ design and installation instructions should always be reviewed in detail prior to installing a CPVC system. In addition to the topics discussed in this Technical Note, the following design and installation topics should also be considered for any CPVC piping project:

- Safety, Handling and Storage
- Hydraulic Design (e.g. pipe sizing)
- Permeation of oxygen through the pipe wall
- Thermal Expansion and Contraction (e.g. expansion arms and loops)
- Cutting and Joining Procedures
- Hangers and Supports
- Heat Transfer / Insulation
- Chemical Compatibility of Ancillary Products (e.g. firestops, thread sealants)

7.0 SUMMARY

Based on the information provided in this Technical Note, it is demonstrated that CPVC piping materials are suitable for high-temperature applications, are resistant to potable water disinfectants, and are suitable for mixed-material piping systems that contain both copper materials (i.e. tubing, fittings, valves) and CPVC, even in cases of dissolved copper ions.

The life expectancy of CPVC piping materials, when specified correctly and installed according to industry and manufacturers’ guidelines, is typically well in excess of fifty (50) years. Long-term pressure ratings for these piping materials are developed based on testing in accordance with ASTM Test Method D2837 and the materials are listed according to PPI TR-3.

Therefore, CPVC piping systems are suitable for many commercial building applications, including hot- and cold-water distribution (potable water plumbing), fire protection, chilled water, and hydronic heating and cooling systems.