

# Design Considerations for CPVC Pipe Sprinkler Systems

Chlorinated polyvinyl chloride (CPVC) pipe has been on the market for more than two decades and appeals to design engineers, contractors, and building owners for various reasons. CPVC pipe is ideal for residential and light hazard commercial applications because of the reduced friction loss and flexibility of the pipe compared to more traditional installations using steel or copper pipe. Additionally, the ease in pipe preparation, the ability for field cutting, and the typically small pipe diameters help to reduce project costs and installation times. These attributes make CPVC a favorable choice for both new and retrofit installations. However, despite these positive attributes, sprinkler system design engineers must be aware of material-specific code requirements and inherent design limitations to avoid potential pitfalls. Otherwise the benefits of using CPVC pipe are lost.

The applicable sprinkler system installation standards for commercial and residential applications—NFPA 13 (2002): *Standard for the Installation of Sprinkler Systems*, NFPA 13D (2002): *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, and NFPA 13R (2002): *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*—allow the use of CPVC pipe and fittings for certain sprinkler system installations in hotels, townhouses, one- and two-family homes, dormitories, office buildings, nursing homes, and similar light hazard applications. Although CPVC is Underwriters Laboratories (UL) listed for use in sprinkler system applications, design engineers must recognize that limitations are imposed on CPVC pipe and fittings according to the specific listing. For projects requiring Factory Mutual (FM) approval, additional limitations may be imposed. These limitations can directly affect the design and installation of sprinkler systems. Unfortunately, these limitations are sometimes overlooked.

This article focuses on some limitations involving CPVC pipe for sprinkler systems. Several examples are provided to illustrate the importance of reviewing applicable installation standards and manufacturers' installation guidelines prior to embarking on a new design. Two of these installations resulted in water losses and one required the replacement of a large portion of a nearly completed system installation.

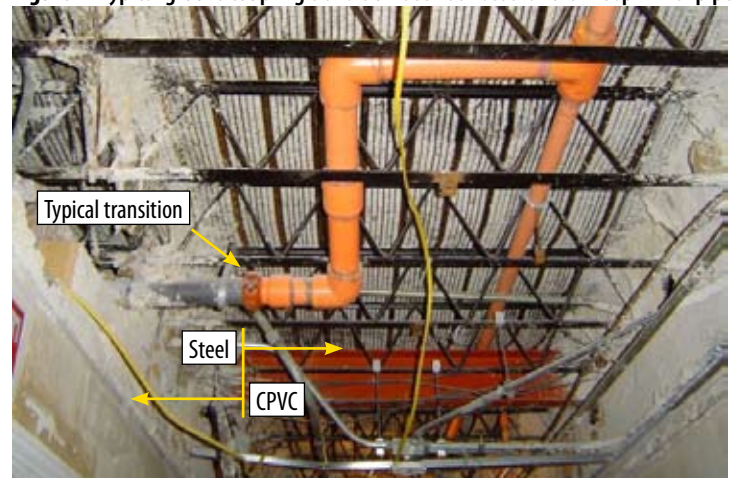
The use of CPVC pipe in sprinkler installations is discussed in NFPA 13 Section 6.3.6.1, which states: "Other types of pipe or tube investigated for suitability in automatic sprinkler installations and listed for this service, including but not limited to polybutylene, CPVC, and steel, differing from that provided in Table 6.3.6.1 (specifically identifies CPVC and polybutylene pipe and corresponding ASTM standards) shall be permitted where installed in accordance with their listing limitations, including installation instructions." Manufacturers recommend that installers obtain proper installation training and renew their training every two years in addition to referencing the installation instructions.

## WHERE CAN CPVC PIPE BE USED?

The use of CPVC is permitted predominantly in residential and light hazard occupancy sprinkler system applications.

CPVC pipe and fittings are also UL listed for limited ordinary hazard sprinkler system applications where ordinary hazard rooms are less than 400 square feet and located in buildings otherwise classified as light hazard, per NFPA 13 (2002) Section 6.3.6.3. Thus, if CPVC is installed in a multiple-use building as defined in the applicable model building code, particular attention must be given to the transition from one occupancy use to the next. A transition to steel or copper pipe is necessary for ordinary hazard areas greater than 400 square feet and extra hazard areas. Figure 1 shows a typical transition. (Although this photograph shows the CPVC pipe supported by the bar joints, additional pipe hangers were added during construction.)

**Figure 1** Typical groove coupling transition between steel and CPVC sprinkler pipes



An example of a misapplication of this provision was recently encountered during an inspection of a sprinkler system being installed in a hotel. The sprinkler system design engineer routed exposed CPVC piping through a large (greater than 400-square-foot) mechanical room and unprotected pipe chases. The contractor was required to redesign the sprinkler system and replace large portions of the completed installation due to oversight of this design constraint.

## DOES CPVC NEED TO BE PROTECTED?

The ability for CPVC pipe to withstand fire is largely dependant on the cooling effects that occur from sprinkler spray discharge. As a result, additional restrictions have been imposed regarding exposed sprinkler system installations using CPVC pipe. It should be noted that the minimum protection required for most applications to be considered concealed requires 3/8-inch gypsum board or 1/2-inch plywood.

In general, unprotected (exposed) CPVC pipe installations are permitted in buildings with smooth, flat horizontal ceiling construction. However, additional restrictions are placed on the type and operating characteristics of the sprinklers. Quick-response ordinary temperature pendent sprinklers spaced at a maximum 15 feet with deflectors located no more than 8 inches below the ceiling, or quick-response ordinary temperature horizontal sidewall sprinklers spaced at a maximum 14 feet with deflectors

located no more than 4–6 inches below the ceiling must be used, according to the 2006 UL *Fire Protection Equipment Directory*.

These limitations are identified in the installation instructions developed by each manufacturer and must be reviewed during the design process to avoid potential problems.

### ARE THERE ANY CHEMICAL AND ENVIRONMENTAL CONSIDERATIONS?

Temperature, ultraviolet light, petroleum-based chemicals, and solvents can affect the integrity of CPVC pipe and fittings.

**High Temperature Conditions.** CPVC is a thermoplastic material, which can soften and lose strength or melt at high temperatures. For this reason an upper service temperature limit of 150°F (66°C) at 175 pounds per square inch is imposed for CPVC pipe applications, per NFPA 13 (2002) Section A.6.3.6. Due to this restriction, consideration must be given to the maximum anticipated ceiling temperature for a given application, such as an attic or small (less than 400-square-foot) mechanical room. Additionally, sprinklers installed with CPVC pipe installations are limited to a maximum temperature rating of 225°F (107°C).

**Freezing Conditions.** Protection against freezing is required if the ambient temperature drops below 40°F (4°C), per NFPA 13 (2002) Section 8.15.3.1.1. In many circumstances dry pipe or pre-action sprinkler systems are used since the pipes in the exposed area(s) are filled with air or nitrogen. However, other than a few limited low-pressure pre-action systems, applications of these options are not typically permissible for use with CPVC pipe. Sprinkler systems using CPVC pipe must be filled with water at all times, e.g. wet pipe. Therefore, there are two permissible methods of protection against freezing: covering the pipe with insulation or using a glycerin-based antifreeze solution (see NFPA 13 (2002) Sections 8.15.3.1.2 and 8.15.3.1.3, NFPA 13D (2002) Sections 8.3.2 and 8.3.3.2, and NFPA 13R (2002) Section 5.3.2).

**Figure 2** Improperly designed and installed sprinkler pipe in a residence



Extreme caution must be exercised when selecting the option to cover the pipe with insulation. Improperly insulating the pipe can lead to system failure. For example, a sprinkler system within a single-family residence was installed during the summer when little consideration likely was given to freezing. Immediately after the first cooling and warming cycle in the winter, a section of the sprinkler pipe froze and broke, causing significant water damage to the house. The sprinkler system used insulation to protect the pipe from freezing and was designed and installed in a manner that made this method of protection against freezing impossible to properly implement. Figure 2 shows a representative example of the system installation.

**Figure 3** Improperly designed and installed sprinkler pipe in an unheated attic



Another example of an improperly installed system is shown in Figure 3. In this instance, the piping for the upper floor was installed in an unheated attic, perpendicular to and above the ceiling joists. Insulation was layered on top of the pipe to prevent water in the pipe from freezing. Someone walking in the attic stepped on the buried pipe and fractured it, causing water flow and substantial loss. After the system was repaired, the building staff decided to keep the pipe exposed to prevent additional breaks, which now makes the system susceptible to freezing. This system likely will need to be replaced or converted to an antifreeze system in the future.

**Combustible Concealed Spaces.** CPVC pipe is not permitted for installation in areas where sprinkler protection is required by NFPA 13, unless special application sprinklers are used. Manufacturers' guidelines must be reviewed in all cases involving combustible concealed spaces.

### ARE THERE ANY MORE CONSIDERATIONS?

Other considerations involve the need for including expansion loops to account for thermal expansion, methods of protection of pipe penetrations through walls, the use of latex-based paints as opposed to oil-based paints, reduced hanger spacing requirements, incompatibility with solvents and chemicals, and pressure testing with water. Additional limitations are identified in the installation instructions and manufacturers' dos and don'ts information pamphlets.

The examples identified in this article, as well as many others, could have been avoided if the sprinkler system designers and installers were aware of the limitations of the materials used in these installations. CPVC will continue to be a good choice for many sprinkler system installation applications as long as the proper level of care is given to ensure that all design considerations have been properly addressed. Make sure that you review the applicable standards and manufacturers' installation guidelines the next time you design a system using CPVC pipe. **PSD**



**MARK HOPKINS, PE**, is a Senior Fire Protection Engineer with Hughes Associates Inc. and a member of the Society of Fire Protection Engineers. For more information or to comment on this article, e-mail [articles@psdmagazine.org](mailto:articles@psdmagazine.org).