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Information File

Fire sprinkler systems and the use of CPVC plastic piping

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In the 1950s, BFGoodrich* invented chlorinated polyvinyl chloride (CPVC) technology, a product of which plastic piping is made. One application of such piping is in fire sprinkler systems.

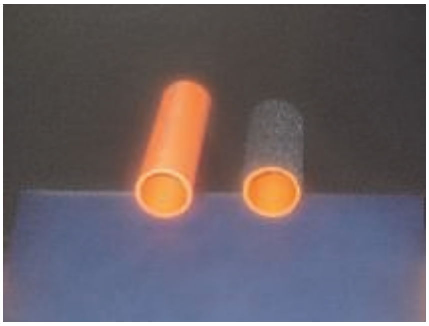
Chlorinated polyvinyl chloride is a post-chlorinated PVC which has no reaction to a wide range of aggressive chemicals, it will not support combustion and it is rated as self extinguishing. An additional feature is its retained strength at high temperatures.

In the 1980s, a special compound formula was developed to suit the demands of a fire sprinkler system for life safety applications. In 1984, the first BlazeMaster® CPVC fire sprinkler systems were deployed in the United States. Since then, BlazeMaster fire sprinkler systems have been performing so successfully that 50% of all NFPA 13 applications in the US are specified with BlazeMaster pipes and fittings.

** BFGoodrich disposed of its chemical division in 2001, the division then became Noveon, Inc. Subsequently Noveon became a subsidiary of the Lubrizol Corporation (2004) and officially changed its name to Lubrizol Advanced Materials, Inc. on 4 June 2007. Lubrizol is the home of BlazeMaster®.*

Chemical and physical attributes of CPVC

BlazeMaster® pipe and fitting compounds are made from chlorinated polyvinyl chloride, which is formed by reacting additional chlorine upon the polyvinyl chloride (PVC) polymer. While PVC contains approximately 57% total chlorine by mass, CPVC has approximately 67%. This additional chlorine content imparts unique performance attributes such as the ability to withstand a direct flame for long periods of time without sustaining combustion or continuing to burn. Instead, the CPVC pipe will char only on the outside wall when exposed to direct flame, while the pipe interior remains smooth.



CPVC has an LOI (Limiting Oxygen Index) of 60. This means that CPVC requires an atmosphere containing 60% oxygen in order to sustain a flame. Since the earth's atmosphere contains only 21% oxygen, the material shows self-extinguishing characteristics and will stop burning the moment the flame is removed.

A charring layer forms on the outside of the pipe when it comes in direct contact with a flame; this layer functions as a thermal barrier and reduces the conduction of heat into the pipe. In addition, CPVC piping systems are approved and used as wet systems only. The moment a sprinkler head activates, the water flow will carry away the heat and thus cool the pipe from the inside, which further reduces the rate of burning.

It is a common misconception that all plastics have the same characteristics with respect to melting and burning. If that was really the case, no plastics, from cable trays to window profiles, would be allowed to be installed on any construction site. Each construction material is rated as to its flammability, including plastic. A common European Fire Classification, developed in accordance with the fire resistance tests in standard EN 13501-1: 2002, provides a more detailed distinction between the different flammability characteristics of material while burning. Submitted to the flammability rating as per EN 13501, the Lubrizol Advanced Materials CPVC has achieved the best possible classification that a non-metal material can achieve, which is Bs1d0:

- Fire behaviour: B = low flammability, no contribution to flashover
- Smoke development: s1 = low smoke development
- Flaming droplets: d0 = no burning drops

Evidence that CPVC systems perform under fire

Fire sprinkler systems using tested and listed CPVC sprinkler pipe have been designed as a life safety system for use in buildings such as hotels, office areas, care homes, hospitals, dormitories, schools, residential applications etc. If exposed day and night, without any interruption, to a constant working pressure of 12bar at a constant working temperature of 65°C, the lifetime of the system has been designed to be 50 years with a safety factor of 2. The following example of a fire in an HMO in Bergen, Norway, demonstrates how well such a system performs in a fire.

In May 2006, a fire broke out in a 1920s apartment building in Bergen, Norway. The fire was caused by a burning cigarette that had dropped from an ashtray and ignited a sofa. All 40 residents in the building were saved from injury or possible death thanks to a CPVC fire sprinkler system, which had been retrofitted as part of a major modernisation project in March, only three months before the fire.

The building has 35 apartments on six floors and had been retrofitted with 175 sprinklers. The chosen sprinkler system offered the residents a low-cost option that provided maximum fire protection with a minimum of disruption during installation. An additional advantage of the fire sprinkler system was that it made a secondary fire escape route unnecessary. This space saving served to increase the floor areas of some of the apartments, which subsequently increased their market value.

CPVC fire sprinkler systems have been in commercial use since 1984 and can contain and even extinguish a fire in less time than it may take for the fire brigade to attend the incident. If a fire is tackled effectively within the first four minutes it can make the difference between life and death. In the case of this apartment building, the timely retrofit demonstrated both the lifesaving function of the CPVC system as well as its role of protecting property.

Installation of CPVC sprinkler systems minimises disruption to tenants

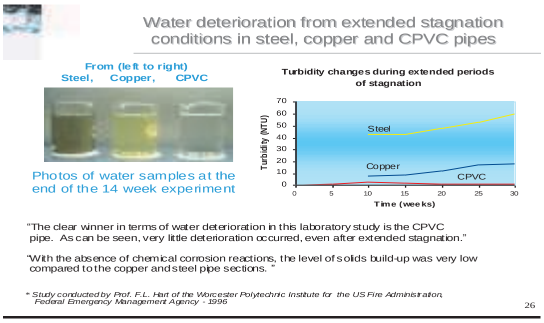
CPVC fire sprinkler systems are known for their light weight, easy handling and fast installation. The (plastic) pipes are so light in comparison to steel or copper pipes that one installer is able to transport the pipes for a system single-handed. This fact contributes to the speed of installation, since the work can easily be split among the installers.

An important advantage of installing a CPVC system is the reduction of noise during installation in an occupied building. Steel and copper pipes need to be cut by an electrical saw and welded by a blowtorch. These processes can introduce potentially hazardous hot working, thus increasing the risk of fire. They also result in loud, high-pitched noises which diminish the quality of life for the residents throughout the process

CPVC fire sprinkler pipes, on the other hand, are cut manually and then solvent-cemented to the fittings, which means there is no noise from saws or threading machines and no fire risk from welding torches. In addition, this technique requires less space on the job site since the tools are considerably smaller and can easily be carried by the installer. Since no cutting oil is used with CPVC pipes, it is easier for the installers to keep the job site clean and not leave oily traces that could possibly damage carpets or wall coverings. The installation technique for CPVC fire sprinkler systems allows the installation to take place without closing down the building and thus eliminates the need to relocate residents and its attendant distress.

No corrosion leads to longer service life and maintains water quality

Tested and listed CPVC pipes and fittings should be WRAS (Water Regulations Advisory Scheme) approved for use with potable water, which is important if the sprinkler system is connected to the main water source.



CPVC systems also offer advantages after installation, in particular with regards to the impact of corrosion on long-term service life and water quality.

The quality of the water contained in a fire sprinkler system can have a corrosive effect on the piping material. Metal piping systems are subject to corrosion. Not only can that reduce the service life of the fire sprinkler system, but it can also cause the standing water in the pipework to deteriorate. In the event of a fire a sprinkler head activates and sprays water onto the flame, and while water damage will be restricted to a limited area (only the sprinkler head closest to the fire will activate), the quality of the water can play a part in the resulting damage.

A prime consideration is the presence of particles of corroded material inside the metal pipe that can become loose and might obstruct the sprinkler head and prevent or reduce the water flow, so that the fire might not be properly controlled. Furthermore, after the fire it can be the case that carpets, wallpaper or even possibly furniture, which might not have suffered too badly from clean water, have been rendered unusable because of the effects of black, contaminated water discharge.CPVC piping systems, on the other hand, are immune to corrosion and designed for a minimum lifetime of 50 years with a safety factor of 2.

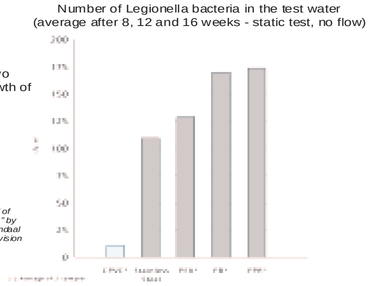
Because of its smooth pipe interior, CPVC pipe can be downsized so that space can be saved. The friction loss in pipe interiors is important for the design of fire sprinkler systems, since it determines the minimum pressure for which the system should be designed. This, in turn, is linked to the Hazen-Williams coefficient, a factor in water flow calculations which represents a pipe's roughness and its effect on fluid flow, with higher values of the coefficient giving lower friction losses. CPVC pipework has a Hazen-Williams coefficient of 150, which remains constant throughout the lifetime of the pipework in a system. Metal systems however, have a lower Hazen-Williams coefficient from the start (120 to 140). This value decreases further over the years due to internal corrosion.

As a study undertaken at Worcester Polytechnic Institute for the US Fire Administration has shown (ref. 1), the quality of water in CPVC plastic piping used for fire sprinkler systems will hardly deteriorate and therefore neither contribute unnecessarily to water damage nor prevent the correct functioning of the sprinkler head.

Biofilm formation and biological growth

In 1999, the KIWA Institute in the Netherlands conducted a study following the request of the Dutch Ministry of Housing, Urban Planning and Environment. KIWA was to determine the biofilm formation potential of different kinds of pipe materials used in plumbing systems. The formation of biofilm within a piping system can contribute to growth of bacteria, such as Legionella pneumophila. The bacteria grows in (preferably) warm water in all kinds of piping systems and is more likely to develop in large buildings with complex water systems, such as hotels, hospitals and care homes.

"In the presence of the two CPVC materials, the growth of Legionella bacteria in the water was low"



* Study : " Biofilm Formation Potential of Pipe materials in Internal Installations " by order of VROM. Authors: H.R. Veenendaal and D. van de Kooiy - KIWA N.V. - Division Chemistry and Biologie. June 1999.

The study (ref.2) has shown that the growth of Legionella is comparably low in CPVC plastic piping materials.

Where can CPVC fire sprinkler systems be installed?

In order to know where CPVC plastic pipework can be installed, it is necessary to determine whether the installation project requires LPCB or UL or FM approval.

In case of LPCB approved projects, check Technical Bulletin 211 of the FPA's publication *LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845*. The Technical Bulletin allows LPCB-approved CPVC systems in Light Hazard applications such as schools, offices, prisons, churches, domestic and residential applications, as well as in Ordinary Hazard 1 applications such as hotels, hospitals, nursing and care homes, colleges, court rooms etc. It also allows the use in museums (OH2), retail sales area (OH3, excluding storage unless for category 1 materials) and theatres, cinemas, auditoriums and concert halls (OH4, excluding stages and prosceniums). TB211 is valid until April 2008, at which time it will be replaced by TB227.

In the case of UL or FM approved projects, check the NFPA standards: NFPA 13 (light hazard occupancies in high rises, nursing homes, offices etc.), NFPA 13D (domestic), NFPA 13R (residential), NFPA 90A (UL approved for use in air plenums) and NFPA 24 (underground piping).

Contractor training

Contractor training is very important. Taking the example of BlazeMaster, all licensed manufacturers of its pipes and fittings and their distributors have assigned trainers who are able to provide CPVC installation training to contractors. This training covers topics such as handling, storage, cutting, chamfering, fitting preparation, joining through solvent cementing, set and cure times, pressure testing, cut-in procedure for existing systems and chemical compatibility of CPVC at the job site. BlazeMaster instructors have a certificate from Lubrizol as proof of their competence as trainers. Fitters who have completed BlazeMaster installation training will receive a certificate and a training card. This is important since more and more approval bodies and authorities make it a requirement that only trained contractors install CPVC systems. In the future, it is likely that relevant authorities will more frequently require contractors to produce such certification. Certificates are normally valid for two years, after which time fitters should receive refresher training.

Summary

This article summarises just a few of the many product advantages that have made tested and listed CPVC sprinkler pipework eminently suitable for use in that application. In order to maximise those advantages, however, it is important that the people who specify and install the product are suitably informed both in the requirements of the codes which relate to the choice of product and also in the practicalities of its installation. Proper training is essential.

References

1. Hart, F.L., Laboratory Study - Water Deterioration from Extended Stagnation Conditions in Steel, Copper and CPVC Pipes, a report prepared at Worcester Polytechnic Institute, USA, for the US Fire Administration, Federal Emergency Management Agency, February 1996.
2. H.R.Veenendaal and D. van de Kooiy, Biofilm formation potential of pipe materials in internal installations, Chemistry and Biology Division, KIWA N.V., 1999.
3. LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845, Fire Protection Association, 2003.

Presented by:

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