

### Introduction

Chlorinated polyvinyl chloride (CPVC) was commercialised in the 1950s by Lubrizol. This thermoplastic polymer is post-chlorinated PVC which can withstand a wide range of aggressive chemicals. Initial applications were piping systems for plumbing and industrial piping. CPVC is derived from petroleum (30-37% of the finished product) and common table salt (63-70%).

In the 1980s, a special compound formula was developed to suit the demands of fire sprinkler systems. 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 over 2 billion feet (600 million metres) of the pipework has been installed in over 60 countries.

### Chemical and Physical Attributes of CPVC

CPVC pipe and fitting compounds are made from a specialty thermoplastic known as chlorinated polyvinyl chloride (CPVC) 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 provides CPVC piping with unique performance attributes such as the ability to withstand direct flame impingement for sustained periods without supporting 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 (see fig 1).

The charring layer, which forms on the outside of the pipe when it comes in direct contact with a flame, functions as a thermal barrier and reduces the conduction of heat into the pipe. The moment a sprinkler head activates, the water flow will carry away any heat thus cooling the pipe from the inside, and further reducing the rate of burning.

CPVC has a Limiting Oxygen Index (LOI) 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.

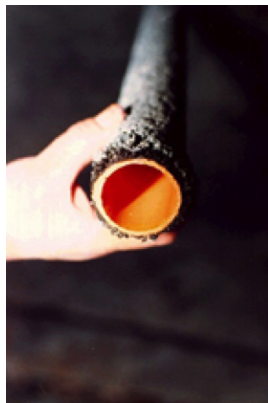


Fig 1: Charring of CPVC pipe

It is a common misconception that all plastics have the same characteristics with respect to melting and burning, however this is not the case. Each construction material including plastic is rated as to its

flammability. Thermoplastics which do not have a rating under BS 476-7 are given a European Fire Classification, as described in the European standard EN 13501-1: 2007, which combines four European fire tests. This standard provides a detailed distinction between the different flammability characteristics of materials whilst burning. When submitted to the flammability rating as per EN 13501, BlazeMaster piping 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

CPVC is pressure rated to a constant working pressure of 12 bar at a constant working temperature of 65degC.

### Benefits of CPVC

CPVC is light and easy to install.

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.

The jointing method (see fig 2) uses solvent cement which creates a molecular level bond between the pipe and fitting. Cement is applied to the pipe, then the fitting, the pipe is inserted into the fitting until the stop and a quarter turn ensures that the cement is spread evenly. Solvent cement cures with a red colour allowing a visual check that joints have been completed.

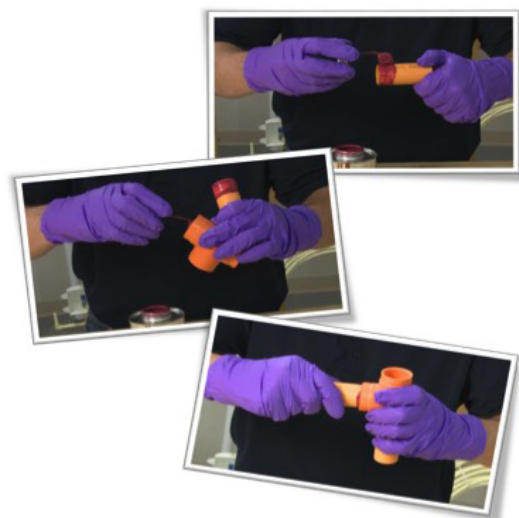


Fig 2 – Solvent Cement jointing process

## CPVC allows for downsizing of pipework

Because of its smooth pipe interior, CPVC pipe can be downsized saving space. Frictional loss in pipe interiors is important in the design of fire sprinkler systems, as it determines the minimum pressure for which the system should be designed. This 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, higher values of the coefficient denoting 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. This means that for an equivalent pressure and flow smaller dimension CPVC piping can be used.

## CPVC is ideal for Retrofit projects

Another important advantage of a CPVC system is the reduction of noise and mess during a retrofit 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, in contrast, are cut manually and then solvent-cemented to the fittings. 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. CPVC pipework was used in the highly successful retrofit of the Callow Mount High Rise block in Sheffield, where the tenants were able to remain in their flats during the retrofitting process (Seaber, 2012, p. 30,46)\*.

Also CPVC was used in the Sheffield low rise retrofit project as mentioned in the BAFSA report (Seaber, 2016, p.11-12)\*\*.

## Water Quality

The water contained in a fire sprinkler system can have a corrosive effect on metallic piping systems. CPVC systems offer advantages after installation, in particular with regards to the impact of corrosion on long-term service life and water quality. CPVC can be installed in concrete if appropriate precautions are taken.

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. CPVC piping systems are immune to corrosion and designed for a minimum service life of 50 years with a safety factor of 2.

A study undertaken at Worcester Polytechnic Institute for the US Fire Administration has shown (see fig 3), that the quality of water in CPVC plastic piping used for fire sprinkler systems suffers minimal deterioration and therefore neither contributes unnecessarily to water damage nor prevents the correct functioning of the sprinkler head.

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality.

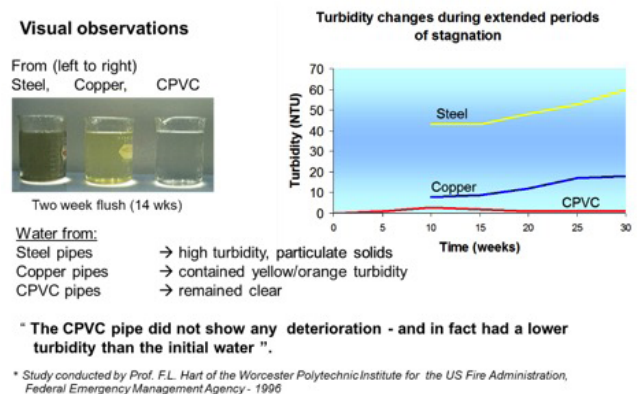


Fig 3: Water Quality and Turbidity in Steel, Copper, CPVC

## Approvals, Listings and Standards

Like all components in a sprinkler system, CPVC pipe and fittings have been rigorously tested by various third party bodies. For example BlazeMaster® passes the UL 1821 (see fig 4), FM 1635, and LPS 1260 testing standards and is UL, C-UL, FM Global and LPCB approved and certified by NSF and WRAS for potable water conveyance.



Fig 4: image from the UL 1821 fire test

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

\*Seaber, S. (2012) Safer High-rise Living, The Callow Mount Sprinkler Retrofit Project. Available at: <http://www.bafsa.org.uk/pdfs/publications/1/00000111.pdf> (Accessed: 22 November 2016).

\*\* Seaber, S. (2016) Sheffield Low Rise Sprinkler Installation. Available at: <http://www.bafsa.org.uk/pdfs/publications/6/00000146.pdf> (Accessed: 22 November 2016).



CPVC can be used in all types of domestic and residential sprinkler systems, for example those designed to the BS 9251:2015 standard (all categories). BlazeMaster is listed in the LPCB 'Red book live' for use in EN 12845: 2009 applications. In the UK check Technical Bulletin 227 of the FPA's publication LPC Rules for Automatic Sprinkler Installations incorporating BS EN 12845. The Technical Bulletin allows FPA -approved CPVC systems in Light Hazard (LH) applications such as schools, offices, prisons, churches, domestic and residential applications, as well as in Ordinary Hazard 1 (OH1) applications such as hotels, hospitals, nursing and care homes, colleges, court rooms etc.

For UL or FM Global approved projects, check the NFPA standards: NFPA 13 (light hazard occupancies in high rises, nursing homes, offices etc.), NFPA 13D (one and two family homes), NFPA 13R (low-rise residential), NFPA 90A (UL listed for use in air plenums) and NFPA 24 (underground piping).

Note that CPVC is only approved for use in wet systems, and should not be specified for Dry or pre-action systems.

### Life Cycle Assessment (LCA)

A Life Cycle Assessment looks at and measures the environmental impact of manufacturing, use and end of life phases of a product.

Lubrizol has completed an ISO-compliant peer reviewed cradle to grave Life Cycle Assessment of BlazeMaster CPVC pipe and fittings (see fig 5).

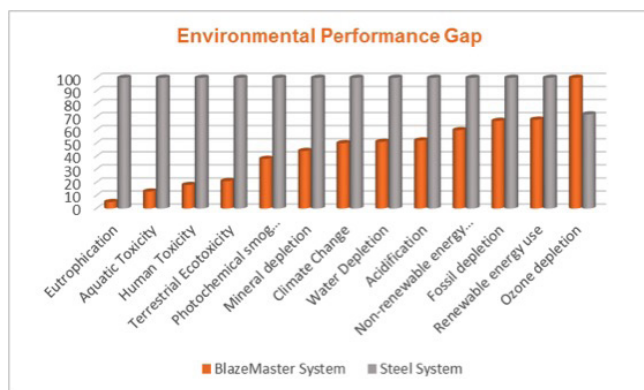


Fig 5: LCA for BlazeMaster® CPVC

### 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. 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.

BAFSA recognised the requirement to install sprinklers as a result of the Welsh Domestic Fire Sprinkler Measure and the increase in new build and retrofit installations in the rest of the UK would lead to a demand for training for contractors. It developed an up-skilling professional development qualification for the Mechanical Services trades who already hold a Level 3 qualification in Domestic Plumbing and Heating and a national Level 2 qualification 'Certificate in Fire Sprinkler Installation covering residential and commercial installation, for those seeking to enter the sector or those with minimal experience.

For further information please contact [qualifications@bafsa.org.uk](mailto:qualifications@bafsa.org.uk)

## Key Do's & Don'ts

A short summary of the key best practices for successful installation of CPVC.

### Expansion and Contraction

CPVC has a higher expansion coefficient than steel, allowance needs to be made in the design for expansion and contraction due to changes in ambient temperature, it is important that hangers and restraints are not too tight, they should allow the pipe to move. Only use hangers that are approved for use with CPVC, for example ones listed by UL.

### Kickback

Positioning of hangers near to sprinkler head drops is critical, the hanger must not allow any kickback of the sprinkler head due to the sudden increase in pressure when the system activates

### Freeze Protection

Glycerin is the only approved anti-freeze agent, and should be pre-diluted. Never use Glycol anti-freeze with CPVC, if possible insulate the pipe with a mineral wool type insulation.

### Chemical Compatibility

CPVC can be affected by certain substances that are found in the building and construction industry, substances containing for example plasticizers, organic oils, petroleum should be checked for

chemical compatibility with CPVC. To ease the burden associated with researching and selecting accompanying construction products, Lubrizol developed the FBC™ System Compatible Program. This resource is made available to manufacturers of ancillary products to assist in determining their product's chemical compatibility with Lubrizol's FlowGuard®, BlazeMaster®, and Corzan® CPVC piping systems. . If an ancillary product is to come into direct contact with a BlazeMaster fire Sprinkler system and is not included in the FBC™ System Compatible Program, Lubrizol recommends that chemical compatibility be confirmed with that product's manufacturer prior to use.

### Cure times

Curing times for solvent cement joints vary by pipe dimension, temperature and humidity, check installation instructions for the relevant charts, and allow for curing prior to pressure testing. Remember to solvent cement Sprinkler head adapters and wait for the cure time to elapse before installing sprinkler heads to avoid any cement getting into the sprinkler head.

### Pressure testing

Pressure testing with compressed gas or air can be dangerous and is not recommended, pressure test with water as per the relevant installation standard.

Presented by

