

Volume II: Fire Protection Systems

Mechanical Technical
Manual Series

SECOND EDITION

BlazeMaster[®]
FIRE SPRINKLER SYSTEMS

Now listed for more types of applications
than any other non-metallic system.

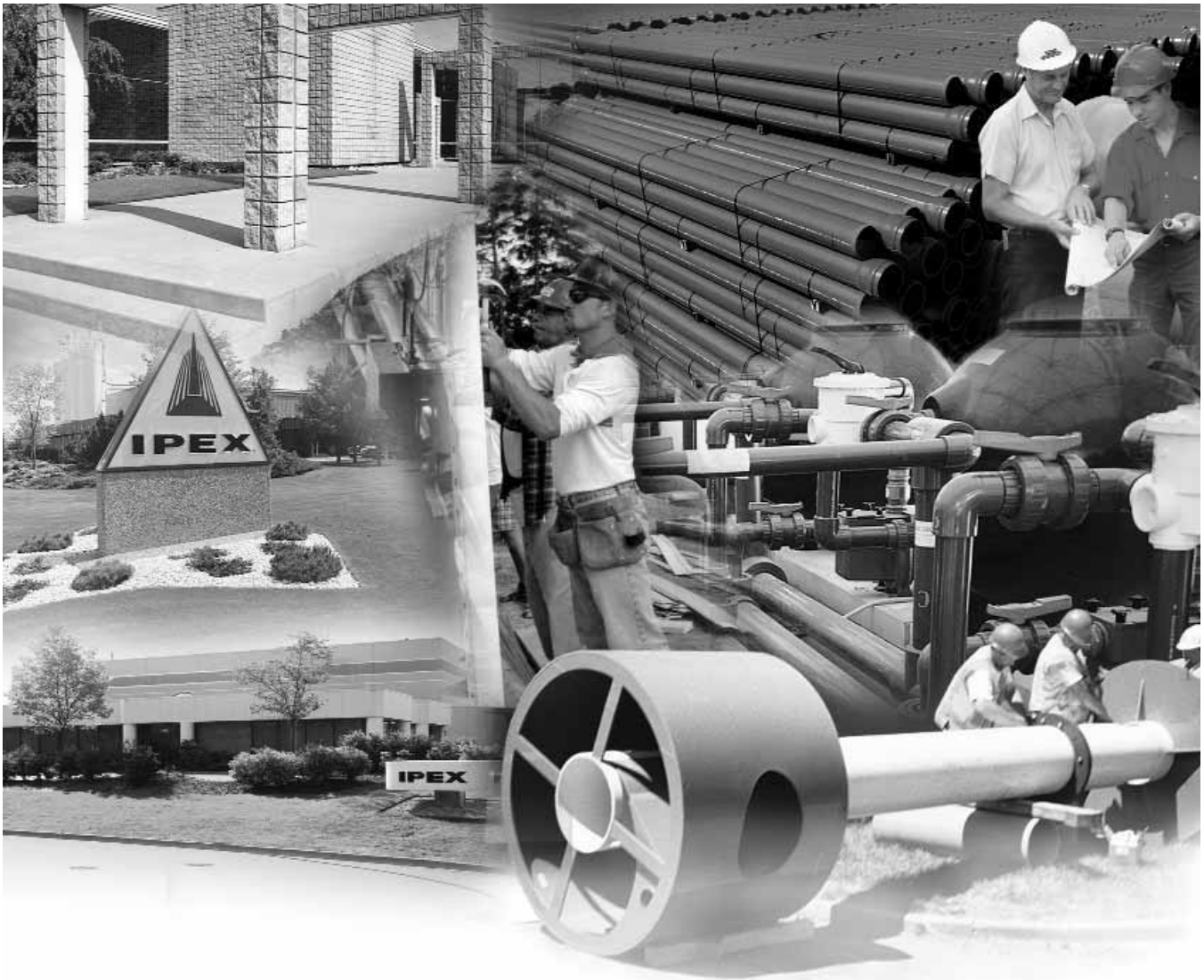


IPEX

BlazeMaster[®] Fire Sprinkler Systems

Mechanical Technical Manual Series Vol. 2. 2nd Edition.

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ABOUT IPEX

At IPEX, we have been manufacturing non-metallic pipe and fittings since 1951. We formulate our own compounds and maintain strict quality control during production. Our products are made available for customers thanks to a network of regional stocking locations throughout North America. We offer a wide variety of systems including complete lines of piping, fittings, valves and custom-fabricated items.

More importantly, we are committed to meeting our customers' needs. As a leader in the plastic piping industry, IPEX continually develops new products, modernizes manufacturing facilities and acquires innovative process technology. In addition, our staff take pride in their work, making available to customers their extensive thermoplastic knowledge and field experience. IPEX personnel are committed to improving the safety, reliability and performance of thermoplastic materials. We and are involved in several standards committees and are members of and/or comply with the organizations listed on this page.

For specific details about any IPEX product, contact our customer service department or visit our technical library at www.ipexinc.com



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OVERVIEW

This manual provides the most up-to-date and comprehensive information about IPEX's BlazeMaster® Fire Sprinkler Systems. All aspects of the BlazeMaster System are covered from basic raw material properties to installation procedures of the finished product. Written with the engineer, contractor and distributor in mind, it is based on laboratory test results combined with IPEX's years of field experience.

This manual is intended as a supplement to basic, fundamental knowledge relating to the installation and/or repair of CPVC fire sprinkler systems. It is the primary source for BlazeMaster installation instructions. Before commencing installation, a user should understand and confirm applicable National Fire Protection Association (NFPA) guidelines and local code approval and installation requirements for CPVC fire sprinkler systems.



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SECTION ONE: GENERAL INFORMATION

FEATURES AND BENEFITS

IPEX BlazeMaster® pipe and fittings are designed specifically for fire sprinkler systems. They are made from a specialty thermoplastic known chemically as post-chlorinated polyvinyl chloride (CPVC). IPEX BlazeMaster pipe and fittings provide unique advantages in sprinkler installations including superior hydraulics, ease of joining, increased hanger spacing in comparison to other thermoplastics and ease of assembly. They also are based on a technology with a continuous and proven service history of more than 40 years.

Lower Installation Costs

In addition to a lower material cost, BlazeMaster pipe and fittings can significantly reduce labor and transportation costs on a typical installation. The reason? Plastics are easily handled, stored, cut and joined. And, heavy equipment used to install metallic and other piping systems are not required, thereby reducing project costs.

Extended Life

IPEX's BlazeMaster System is fundamentally ageless and impervious to normal weather conditions. BlazeMaster Systems in uninterrupted service have operated successfully for over 18 years. During maintenance or revisions, examinations of the original plastic materials showed excellent physical and hydraulic characteristics.

Once properly selected for the application and correctly installed, IPEX BlazeMaster provides years of maintenance-free service. Our materials will not rust, pit, scale or corrode on either interior or exterior surfaces.

Improved Flow

IPEX piping has a substantially lower Roughness Factor than metal and other materials, and since BlazeMaster CPVC does not rust, pit, scale or corrode, the interior walls remain smooth in virtually any service. This high carrying capacity may result in the use of flatter grades or smaller diameter pipe.

Fire Performance

BlazeMaster is made with CPVC which offers an even greater fire safety profile than PVC. Like PVC, CPVC will not independently support combustion, and as such will not burn once the flame source is removed. CPVC's ignition resistance is demonstrated by its flash ignition temperature of 900°F.

CPVC also has a low flame spread. In addition, it provides outstanding smoke characteristics. In testing conducted to CAN/ULC S102.2, CPVC showed a flame spread of less than 15, and a smoke-developed classification of 15. And, like PVC, CPVC has a fuel contribution of 0.

Extensive tests on PVC and CPVC compounds prove their outstanding fire performance. These materials meet the most stringent requirements governing the use of combustible pipe in most building types.



Applications

BlazeMaster Fire Sprinkler Systems offer a level of superior performance that exceeds your requirements:

- Fully approved for use in all NFPA 13 Light Hazard applications
- Field fabrication reduces design engineering
- Smooth inner surface allows pipe downsizing with superior hydraulics – Hazen-Williams “C” factor of 150
- Great in corrosive environments – immune to Microbiology Influenced Corrosion (MIC)
- Higher occupancy rate compared to metal retrofits
- Less impact on occupants during retrofits
- Design savings
- Concealed and exposed, UL and ULC Listed for use in NFPA 13, 13R, and 13D Light Hazard applications including high rise buildings
- FM Approved, NSF certified, and permitted for use in air plenums per NFPA 90A



SECTION TWO: INDUSTRY STANDARDS AND GUIDELINES

IPEX BlazeMaster CPVC pipe carries the markings of Underwriters' Laboratories of Canada (ULC), and Underwriters Laboratories Inc. (UL) and Factory Mutual (FM). BlazeMaster is listed by NSF International (NSF) when potable water is used. Refer to individual manufacturers' installation instructions for specific listings and approvals.

Combination of IPEX BlazeMaster Products with other CPVC and Solvent Cements

IPEX BlazeMaster CPVC pipe and fittings are UL and ULC Listed for use with IPEX and/or other BlazeMaster CPVC pipe and/or BlazeMaster CPVC fittings Listed in accordance with the appropriate U.S. and/or Canadian requirements.

The BlazeMaster products' listing does not include the combination of IPEX BlazeMaster CPVC pipe with other types of specially listed CPVC fire sprinkler pipes, fittings and solvent cements.

Where to Use IPEX BlazeMaster Fire Sprinkler Systems

IPEX BlazeMaster CPVC pipe and fittings are Listed by Underwriters' Laboratories of Canada (ULC) and Underwriters Laboratories Inc. (UL) for use in:

- Light Hazard occupancies as defined in the Standard for Installation of Sprinkler Systems, NFPA 13.
- Residential occupancies as defined in the Standard for Installation of Sprinkler Systems in Residential Occupancies up to Four Stories in Height, NFPA 13R.
- Residential occupancies as defined in the Standard for Sprinkler Systems in One and Two Family Dwellings and Manufactured Homes, NFPA 13D.
- Air plenums, as defined by the Installation of Air Conditioning and Ventilating Systems, NFPA 90A.
- Underground Water Pressure Service, NFPA 24 at a maximum working pressure of 1210 kPa (175 psi).
- System risers in residential buildings up to four stories in height, NFPA 13R and 13D, when protected, at a maximum working pressure of 1210 kPa (175 psi).

IPEX BlazeMaster fire sprinkler systems shall be employed in wet-pipe systems only. (A wet-pipe system contains water and is connected to a water supply so that the water will discharge immediately when the sprinkler is opened.) BlazeMaster CPVC pipe and fittings must never be used in a system using compressed air or other gases. National Fire Protection Association Standards 13, 13R, 13D, the Building Code of Canada and NFPA 24 must be referenced and followed for design and installation requirements in conjunction with this design manual.

Concealed Installations

With concealed installation the minimum protection shall consist of one layer of $\frac{3}{8}$ " (9.5 mm) gypsum wallboard, or a suspended membrane ceiling with lay-in panels or tiles having a weight of not less than 0.35 pounds per square foot (1.7 kg per square meter) when installed with metallic support grids, or $\frac{1}{2}$ " (12.7 mm) plywood soffits.

For residential occupancies defined in NFPA 13R and 13D, the minimum protection may consist of one layer of $\frac{1}{2}$ " (12.7 mm) plywood. During periods of remodeling and renovation, appropriate steps must be taken to protect the piping from fire exposure if the ceiling is temporarily removed.

In concealed installation, the sprinkler temperature rating is 77°C (170°F) or lower. In accordance with the ULC Listing, the effectiveness of this protection can be impaired if penetrated by large openings such as ventilation grills; exhaust fans connected to metal ducts serving washrooms excepted. Where such penetration is present, individual openings exceeding 0.03 m² but not exceeding 0.71 m² in area must be located so that the distance from the edge of the opening to the nearest sprinkler does not exceed 300 mm. This piping shall not be used where such openings exceed 0.71 m² in area. The effect of the presence of non-rated recessed lighting fixtures, public address speakers and other interruptions of the protective membrane has not been investigated.

Unfinished Basements with Exposed Solid Wood Joist

Note: Check with your IPEX representative or local building code for use of system before installing in unfinished basements.

In accordance with the UL and ULC Listing, IPEX BlazeMaster CPVC Sprinkler Pipe and Fittings may be installed without protection (exposed) in unfinished basements in accordance with NFPA 13D when subject to the following additional limitations:

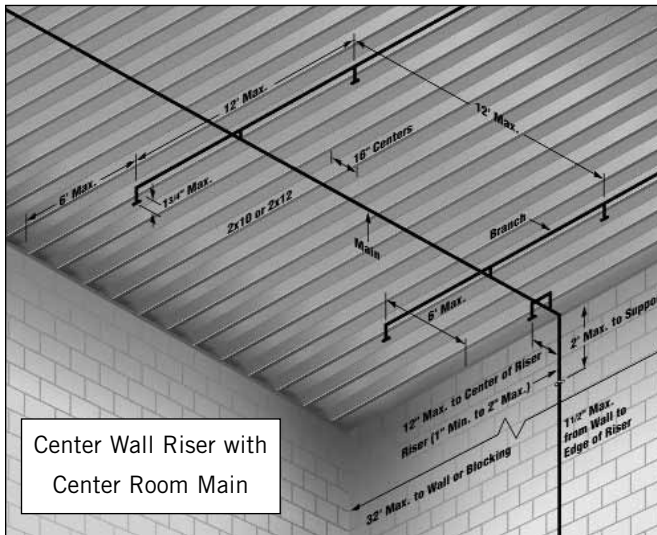
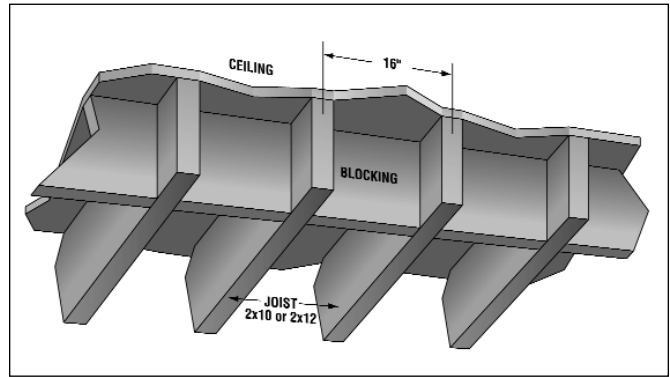
1. The ceiling shall be horizontal and constructed utilizing nominal 2" x 10" solid wood joists on 16" centers.
- OR
- The ceiling shall be horizontal and constructed utilizing nominal 2" x 12" solid wood joists on 16" centers. When installing IPEX BlazeMaster CPVC pipe and fittings in conjunction with 2" x 12" solid wood joists, the maximum system working pressure under flowing conditions shall not exceed 100 psi and the maximum system working pressure under static (nonflowing) conditions shall not exceed 175 psi.
 2. The distance from the floor to the bottom of the solid wood joists shall be between 7' and 8'.
 3. Listed residential pendent sprinklers with a maximum temperature rating of 155°F and a minimum K-factor of 3.0 are to be used for this type of installation. The maximum sprinkler spacing shall not exceed 12 feet. The system is to be designed based upon the Listed flows for the sprinkler selected except that the flow for a single sprinkler flowing is to be not less than 10 gpm and the flow for multiple sprinklers flowing is to be not less than 8 gpm per sprinkler. The sprinklers are to be installed with their deflectors a maximum of 1³/₄ " below the bottom of the solid wood joists in anticipation of future installation of a finished ceiling. (reference NFPA 13D, Section 4-2.4, 1999 Edition)

4. All system mains shall be run perpendicular to the joists. All branch lines shall be run parallel to the joists. Schedule 80 fittings in the 1-1/2 in. and larger size shall be used.
5. All solvent cement joints shall be made with IPEX BlazeMaster (BM-5) One Step Solvent Cement.
6. When the total protected area exceeds 1,000 square feet, blocking shall be utilized to divide the area into individual compartments not exceeding 1,000 square feet. The maximum length along the joist shall not exceed 32 feet. When the length exceeds 32 feet, blocking shall be utilized. The blocking shall be constructed of minimum 1/2 in. plywood and shall be the full depth of the wood joists. It is acceptable for items such as piping, wires, ducts, etc. to penetrate the blocking. The gap between the item penetrating the blocking should be minimized. For installations where the gap exceeds 1/4 in., the gap shall be filled with insulation, caulking, or other suitable material.
7. When installing IPEX BlazeMaster CPVC pipe perpendicular (system mains) to the solid wood joists, listed support devices for thermoplastic sprinkler piping or other listed support devices shall be used which mount the piping directly to the bottom of the solid wood joists. As an alternative to mounting the pipe and fittings below the solid wood joists, it is also acceptable to cut holes in the solid wood joists at or below the center of the depth of the solid wood joist for support – the holes should be oversized to allow for movement and located to not impair the structural integrity of the joists.

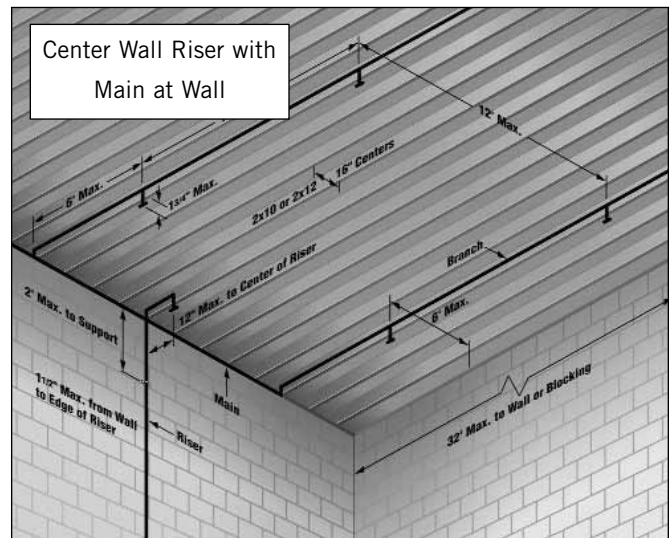
CAUTION: When drilling holes in the solid wood joists, the structural integrity must be maintained. Consult the Authority Having Jurisdiction (AHJ) or building code for requirements.

8. When installing IPEX BlazeMaster CPVC pipe parallel (branch lines) to the solid wood joists, the pipe and fittings shall be installed in the cavity below the bottom of the ceiling and above the bottom of the joist. The branch lines shall be located at or below the center of the depth of the solid wood joist. The pipe shall be installed utilizing listed support devices for thermoplastic sprinkler piping or other listed support devices which mount the piping directly to nominal 2" wood blocking or listed support devices for thermoplastic sprinkler piping which offset the pipe a nominal distance of 1-1/2 in. from the solid wood joists.

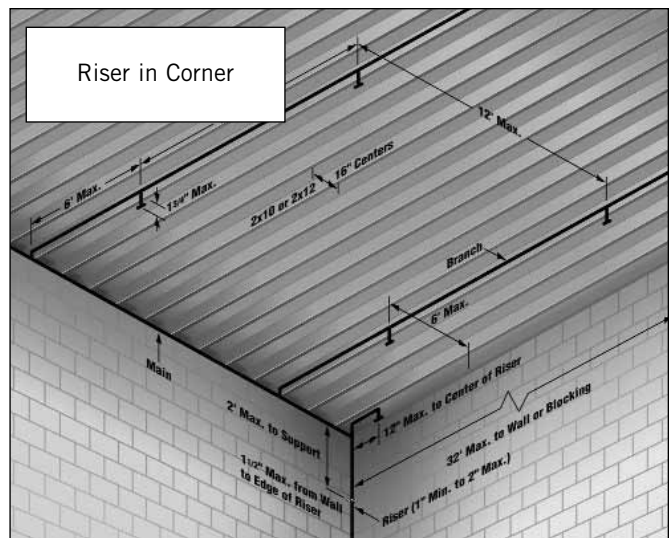
Use of IPEX BlazeMaster CPVC pipe and fittings is limited to basements where the quantity and combustibility of contents is low and fires with relatively low rates of heat release are expected.



Center Wall Riser with Center Room Main

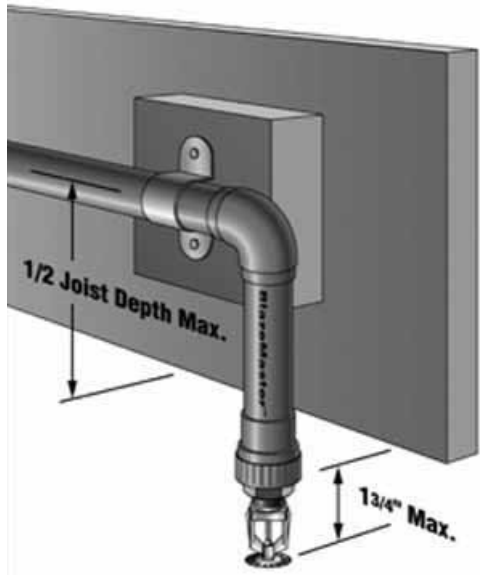


Center Wall Riser with Main at Wall

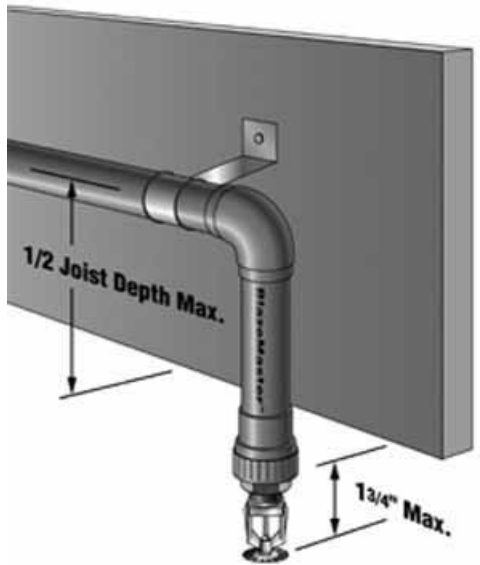


Riser in Corner

Branches supported
with Blocking



Branches supported
with Hangers



Exposed Installations (Where Sprinklers are Required)

BlazeMaster CPVC pipe and fittings are not Listed for installation in combustible spaces requiring sprinklers, as referenced NFPA 13. However, NFPA 13R and 13D permit the omission of sprinklers from combustible concealed spaces and BlazeMaster pipe and fittings can be installed in these areas when protecting residential occupancies according to these standards.

As an alternative to the protection requirements, BlazeMaster pipe and fittings may be installed without protection (exposed), subject to the following additional limitations:

Smooth, flat, horizontal fixed ceilings

1. Exposed piping is to be installed below a smooth, flat, horizontal fixed ceilings in conjunction with Listed quick response or residential sprinklers of maximum temperature rating of 77°C (170°F).
2. Listed Quick-Response pendent sprinklers having deflectors installed within 8" (203 mm) from the ceiling or Listed Residential pendent sprinklers located in accordance with their Listing and a maximum distance between sprinklers not to exceed 15' (4.57 m).
3. Listed Quick Response horizontal sidewall sprinklers having deflectors installed within 6" (152 mm) from the ceiling and within 4" (101 mm) from the sidewall or Listed Residential horizontal sidewall sprinklers located in accordance with their Listing and a maximum distance between sprinklers not to exceed 14' (4.27 m).
4. Exposed pipe employing Listed Quick Response upright heads shall be installed not more than 7½" (190 mm) from the ceiling to the centerline of the pipe. Upright heads shall be installed having the deflectors within 4" (101 mm) from the ceiling and a maximum distance between sprinklers not to exceed 15' (4.57 m). For upright heads, the maximum distance from the centerline of a sprinkler head to a hanger shall be 3" (76.2 mm).

Factory Mutual

Factory Mutual (FM) insured properties require the pipe to be protected by a permanent non-removable fire resistant barrier. Exposed pipe and drop in ceiling panels are not acceptable.

Combustible Concealed Installations

IPEX BlazeMaster pipe and fittings must never be installed in combustible concealed spaces requiring sprinklers, as referenced in NFPA 13.

NFPA 13R and 13D

NFPA 13R and 13D permit the omission of sprinklers from combustible concealed spaces and IPEX BlazeMaster pipe and fittings may be installed in these areas when sprinklering residential occupancies according to these standards.



Extended Coverage Sprinklers

In accordance with the UL and ULC Listing, IPEX BlazeMaster CPVC Sprinkler Pipe and Fittings may be installed without protection (exposed) with Listed Extended Coverage Sprinklers when subject to the following additional limitations:

- Exposed piping is to be installed below a smooth, flat, horizontal ceiling construction.
- When using fittings that are 1½ inch or greater, only schedule 80 fittings may be used.
- The end use application is limited to unobstructed construction.
- All solvent cement joints shall be made with BlazeMaster (BM-5) One Step Solvent Cement.

The new listing allows listed pendent, light hazard, quick response, extended coverage sprinklers AND listed residential pendent sprinklers with a 155°F maximum temperature rating to have deflectors installed within 8" from the ceiling. The distance between sprinklers may range from 15 to 20' with a minimum application density of 0.10 gpm/sq. ft.

Previously, the listing was restricted to quick response pendent sprinkler heads with a limitation of 15' spacing between the heads.

In addition, the new listing allows listed horizontal sidewall, light hazard, quick response, extended coverage sprinklers AND listed horizontal sidewall residential sprinklers with a 165°F maximum temperature rating to have deflectors installed within 6" from the ceiling and within 4" from the sidewall. The distance between sprinklers may range from 14' to 18' with an application density of at least 0.10 gpm/sqft. The listing had been restricted to quick response horizontal sidewall sprinkler heads with a limitation of 14' spacing between heads.

Before beginning installation the manufacturer's installation instructions must be referenced for complete information regarding installation. Additional requirements may be listed in NFPA 13, 13D and 13R.

Only CPVC cements approved by IPEX can be used with BlazeMaster pipe and fittings.

Summary

Sprinkler Type	Existing UL Listing sprinkler head spacing requirements	New, additional UL Listing sprinkler head spacing options
Pendent	15' maximum	20' maximum
Sidewall	14' maximum	18' maximum

Air Plenums

In accordance with the UL and ULC Listing, IPEX BlazeMaster CPVC Sprinkler Pipe and Fittings are approved for use in air plenums. IPEX BlazeMaster CPVC Sprinkler Pipe and Fittings have been investigated by UL per the requirements of UL 1887 and found to comply with the combustibility requirements for thermoplastic sprinkler pipe as described in the Standard for Installation of Air Conditioning and Ventilating Systems, NFPA 90A and various model mechanical codes. (Note: IPEX BlazeMaster CPVC Sprinkler Pipe and Fittings may be installed in the plenum adjacent to, but not over, openings in the ceiling such as ventilation grills and require the use of Schedule 80 fittings in the 1½" and larger size.)

System Risers in NFPA 13R and 13D Applications

BlazeMaster CPVC pipe and fittings may be used as system risers in accordance with NFPA 13D and 13R when subject to the following additional limitations:

1. When installed protected (concealed), the minimum protection shall consist of either one layer of 9.5 mm (¾") thick gypsum wallboard or 12.7 mm (½") thick plywood.
2. In accordance with the UL and ULC Listing, when installed without protection (exposed), the following limitations shall apply:
 - a) The riser shall be installed below a smooth, flat, horizontal ceiling construction. A Listed residential pendent sprinkler is to be installed with its deflector at the distance from the ceiling specified in the sprinkler Listing.

OR

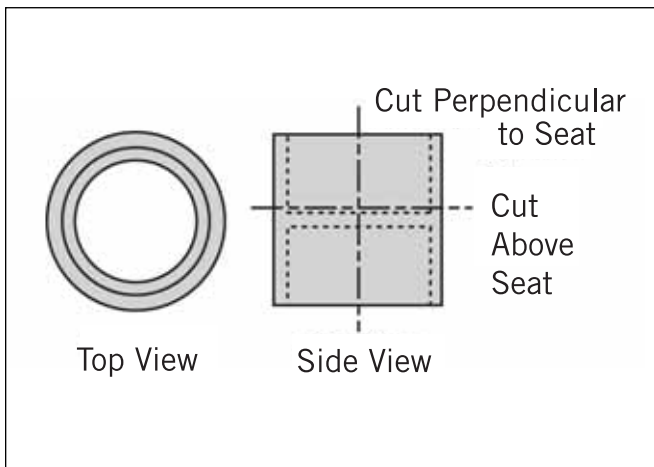
The riser shall be installed below a horizontal unfinished basement ceiling (in accordance with NFPA 13D) constructed utilizing nominal 2" x 10" or nominal 2" x 12" exposed solid wood joists on 16" centers. A Listed residential pendent sprinkler is to be installed with its deflector a maximum of 1¾" below the bottom of the solid wood joist in anticipation of future installation of a finished ceiling.

 - When installing BlazeMaster CPVC pipe and fittings in conjunction with 2" x 12" solid wood joists, the maximum system working pressure under flowing conditions shall not exceed 100 psi and the maximum system working pressure under static (nonflowing) conditions shall not exceed 175 psi.
 - b) A listed residential pendent sprinkler having a maximum temperature rating of 155°F and a minimum K-factor of 3.0 is to be installed at a maximum horizontal distance of 12" from the centerline of the riser. The system is to be designed based upon the Listed flows for the sprinkler selected except that the flow for a single sprinkler flowing is to be not less than 10 gpm and the flow for multiple sprinklers flowing is to be not less than 8 gpm per sprinkler.
 - c) The riser shall be supported vertically within two feet of the ceiling or bottom of the joist.
 - d) The minimum riser diameter shall be 1" and the maximum riser diameter shall be 2". Schedule 80 fittings for riser sizes 1½" and larger shall be used.

- e) The maximum distance between the wall(s) and the outside surface of the riser pipe shall be 1½".
- f) All solvent cement joints shall be made with BlazeMaster One Step Solvent Cement (BM-5).
- 3. The system shall be installed per the requirements of NFPA 13, Sections 6-2.5 (1999 Edition), Support of Risers.
- 4. The BlazeMaster CPVC sprinkler pipe and fittings shall be installed per the manufacturer's installation and design manual.
- 5. Risers shall be supported by pipe clamps or by hangers located on the horizontal connection close to the riser. Only Listed hangers and clamps shall be used.
- 6. Vertical lines must be supported at intervals, described in 7 & 8 below, to avoid placing excessive load on a fitting at the lower end. Do this by using riser clamps or double bolt pipe clamps Listed for this service. The clamps must not exert compressive stresses on the pipe. If possible, the clamps should be located just below a fitting so that the shoulder of the fitting rests against the clamp. If necessary, a coupling can be modified and adhered to the pipe as a bearing support such that the shoulder of the fitting rests on the clamp. Follow the manufacturer's recommended cure time.

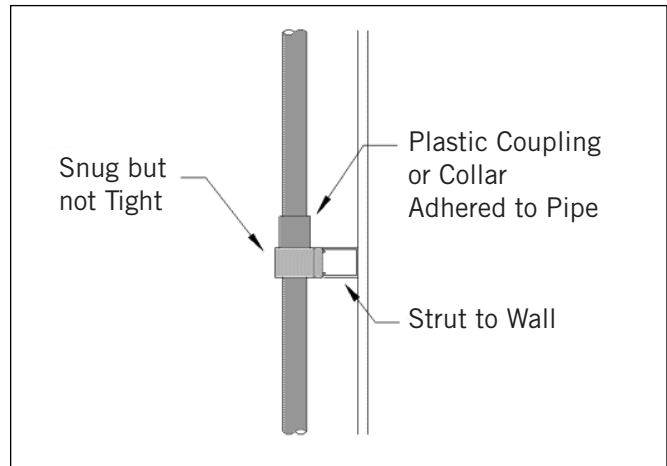
Recommended method for securing BlazeMaster pipe vertically. Place clamp below shoulder of fitting.
WARNING: Modified riser collar shall only be used to provide support to the riser and shall not be used to join two pieces of pipe.

Figure 1: Field Modification for Riser Collar for Vertical Use



Modified BlazeMaster CPVC Coupling Adhered to Pipe

Figure 2: Coupling Modification for Riser Collar



- 7. Do not use riser clamps that squeeze the pipe and depend on compression of the pipe to support the weight.
- 8. Hangers and straps shall not compress, distort, cut or abrade the piping and shall allow for free movement of the pipe to allow for thermal expansion and contraction.
- 9. Maintain vertical piping in straight alignment with supports at each floor level, or at 10 feet (3.05 m) intervals, whichever is less.
- 10. CPVC risers in vertical shafts or in buildings with ceilings over 25' (7.62 m), shall be aligned straightly and supported at each floor level, or at 10' (3.05 m) intervals, whichever is less.

SECTION THREE: MATERIAL PROPERTIES

Pressure Rating

BlazeMaster pipe and fittings (20 – 80 mm (¾" – 3")) are rated for continuous service of 1207 kPa (175 psi) at 65°C (150°F).

Pipe Dimensions & Weights

IPEX BlazeMaster pipe is produced in SDR 13.5 dimensions. SDR, or standard dimensional ratio, means the pipe wall thickness is directly proportional to the outside diameter. This results in all diameters carrying the same pressure capability. IPEX BlazeMaster pipe is produced to the specifications of ASTM F 442. IPEX BlazeMaster fittings are produced to ASTM F 437, F 438, or F 439 specifications depending on the size and configuration.

IPEX BlazeMaster Pipe Dimensions & Weights

SDR 13.5 (ASTM F 442)

Nominal Size	Average OD		Average ID		lbs /ft	Kgrams /mtr	lbs /ft	Kgrams /mtr	
	In	mm	In	mm	Empty	Empty	H2O Filled	H2O Filled	
¾"	19.05	1.050	26.67	.874	22.2	0.168	0.250	0.428	0.637
1"	25.40	1.315	33.40	1.101	28.0	0.262	0.390	.0675	0.100
1¼"	31.75	1.660	42.16	1.394	35.4	0.418	0.622	1.079	1.606
1½"	38.10	1.900	48.26	1.598	40.6	0.548	0.816	1.417	2.109
2"	50.80	2.375	60.33	2.003	50.9	0.859	1.278	2.224	3.310
2½"	63.50	2.875	73.03	2.423	61.5	1.257	1.871	3.255	4.844
3"	76.20	3.500	88.90	2.950	75.0	1.867	2.778	4.829	7.186

Note: The above average OD and average ID information is per ASTM F442. Check with individual manufacturers for actual OD and ID information.

Physical and Thermal Properties of BlazeMaster CPVC

Property	CPVC	ASTM
Specific Gravity	1.55	D 792
IZOD Impact Strength (ft. lbs./inch, notched)	3.0	D 256A
Modulus of Elasticity, @ 73°F, psi	4.23 x 10 ⁵	D 638
Ultimate Tensile Strength, psi	8,400	D 638
Compressive Strength, psi	9,600	D 695
Poisson's Ratio	.35 - .38	-
Working Stress @ 73°F, psi	2,000	D 1598
Hazen-Williams C Factor	150	-
Coefficient of Linear Expansion in./in.°F)	3.4 x 10 ⁻⁵	D 696
Thermal Conductivity BTU/hr.ft.²°F/in.	0.95	C 177
Limiting Oxygen Index	60%	D 2863
Electrical Conductivity	Non Conductor	



Sprinkler Head Temperature Ratings

BlazeMaster pipe and fittings shall be used in sprinkler systems employing sprinkler heads rated 77°C (170°F) or lower, for pendent and horizontal sidewall heads. Quick-Response upright heads shall be rated at 68°C (155°F) or less.

Temperature/Pressure Rating

BlazeMaster pipe and fittings (20 – 80 mm (¾" – 3")) are rated for continuous service of 1207 kPa (175 psi) at 65°C (150°F). IPEX BlazeMaster pipe and fittings are suitable for use in areas where ambient temperatures are within the range of 2°C (36°F) to 65°C (150°F). IPEX BlazeMaster pipe can be installed in an area, such as an attic, where the temperature will exceed 65°C (150°F) if ventilation is provided or if insulation is used around the pipe to maintain a cooler environment. BlazeMaster piping systems must be laid out so that the piping is not closely exposed to devices that generate heat in excess of 65°C (150°F) such as light fixtures, ballasts and steam lines. If the installation is in an area subject to freezing temperatures, the sprinkler system must be protected from freezing. A frozen system will not only be deactivated, but the pressures that may build up can cause the sprinkler heads to open or damage the pipes.

Hydraulic Design

C Factor

Hydraulic calculations for the sizing of BlazeMaster pipe and fittings shall be calculated using the Hazen-Williams C factor of 150.

Pipe Friction Loss

Pipe friction loss calculations shall be made according to NFPA 13 Section 8-4 (1999 Edition).

Fittings Friction Loss

The following table shows the allowance for friction loss for fittings, expressed as equivalent length of pipe.

**Allowance for Friction Loss in Fittings
(SDR 13.5 Equivalent Pipe)**

		20 mm (¾")	25 mm (1")	32 mm (1¼")	40 mm (1½")	50 mm (2")	65 mm (2½")	80 mm (3")
Tee Branch	<i>m</i> (<i>ft</i>)	0.91 (3)	1.52 (5)	1.83 (6)	2.44 (8)	3.05 (10)	3.66 (12)	4.57 (15)
Elbow 90°	<i>m</i> (<i>ft</i>)	2.13 (7)	2.13 (7)	2.44 (8)	2.74 (9)	3.35 (11)	3.66 (12)	3.96 (13)
Elbow 45°	<i>m</i> (<i>ft</i>)	0.31 (1)	0.31 (1)	0.61 (2)	0.61 (2)	0.61 (2)	0.91 (3)	1.22 (4)
Coupling	<i>m</i> (<i>ft</i>)	0.31 (1)	0.31 (1)	0.31 (1)	0.31 (1)	0.31 (1)	0.61 (2)	0.61 (2)
Tee Run	<i>m</i> (<i>ft</i>)	0.31 (1)	0.31 (1)	0.31 (1)	0.31 (1)	0.31 (1)	0.61 (2)	0.61 (2)

Thermal Expansion and Contraction

IPEX BlazeMaster CPVC pipe, like all piping materials, expands and contracts with changes in temperature. The coefficient of linear expansion is: 0.0000612 cm / cm °C (0.0000340 inch/inch-°F). Lineal expansion is the same for all pipe diameters.

Thermal Expansion in Inches

Formula: $\Delta L = L_p C (\Delta T)$

Where: ΔL = change in length due to change in temperature in inches

L_p = length of pipe in inches

C = coefficient of thermal expansion 3.4×10^{-5} inch / inch °F

ΔT = change in temperature °F

Example

$L_p = 30 \text{ ft} = 360"$

$\Delta T = 25^\circ\text{F}$

$\Delta L = 360 \times 3.4 \times 10^{-5} (25)$
 $= 0.31"$

Temp Change ΔT °F	Length of Run in Feet													
	5	10	15	20	25	30	35	40	45	50	70	90	120	160
Thermal Expansion ΔL (in.)														
20	0.04	0.08	0.12	0.16	0.20	0.24	0.29	0.33	0.37	0.41	0.57	0.73	0.98	1.31
30	0.06	0.12	0.18	0.24	0.31	0.37	0.43	0.49	0.55	0.61	0.86	1.10	1.47	1.96
40	0.08	0.16	0.24	0.33	0.41	0.49	0.57	0.65	0.73	0.82	1.14	1.47	1.96	2.61
50	0.10	0.20	0.31	0.41	0.51	0.61	0.71	0.82	0.92	1.02	1.43	1.84	2.45	3.26
60	0.12	0.24	0.37	0.49	0.61	0.73	0.86	0.98	1.10	1.22	1.71	2.20	2.94	3.92
70	0.14	0.29	0.43	0.57	0.71	0.86	1.00	1.14	1.29	1.43	2.00	2.57	3.43	4.57
80	0.16	0.33	0.49	0.65	0.82	0.98	1.14	1.31	1.47	1.63	2.28	2.94	3.92	5.22
90	0.18	0.37	0.55	0.73	0.92	1.10	1.29	1.47	1.65	1.84	2.57	3.30	4.41	5.88
100	0.20	0.41	0.61	0.82	1.02	1.22	1.43	1.63	1.84	2.04	2.86	3.67	4.90	6.53

DESIGN DATA

Thermal Expansion in Centimeters

Formula: $\Delta L = L_p C (\Delta T)$

Where: ΔL = change in length due to change in temperature in cm

L_p = length of pipe in cm

C = coefficient of thermal expansion 6.2×10^{-5} inch / inch $^{\circ}\text{C}$

ΔT = change in temperature $^{\circ}\text{C}$

Example

$L_p = 10$ Meters = 1000 cm

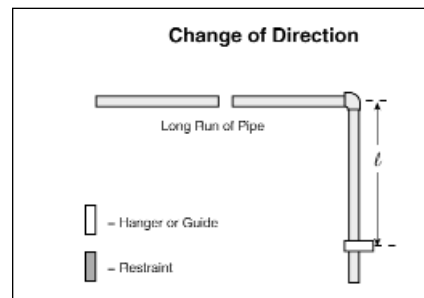
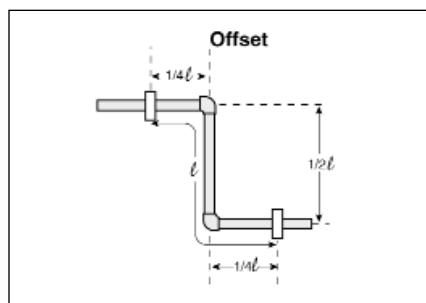
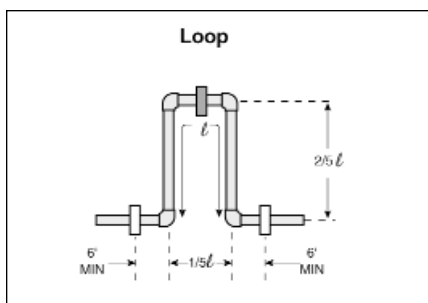
$\Delta T = 25^{\circ}\text{C}$

$\Delta L = 1000 \times 6.12 \times 10^{-5} (25)$

= 1.55 cm

Temp Change ΔT $^{\circ}\text{C}$	Length of Run in Meters													
	1	2	4	6	8	10	12	14	16	18	20	30	40	50
	Thermal Expansion ΔL (cm.)													
10	0.06	0.12	0.24	0.37	0.49	0.61	0.73	0.86	0.98	1.10	1.22	1.84	2.45	3.06
15	0.09	0.18	0.37	0.55	0.73	0.92	1.10	1.29	1.47	1.65	1.84	2.75	3.67	4.59
20	0.12	0.24	0.49	0.73	0.98	1.22	1.47	1.71	1.96	2.20	2.45	3.67	4.90	6.12
25	0.15	0.31	0.61	0.92	1.22	1.53	1.84	2.14	2.45	2.75	3.06	4.59	6.12	7.65
30	0.18	0.37	0.73	1.10	1.47	1.84	2.20	2.57	2.94	3.30	3.67	5.51	7.34	9.18
35	0.21	0.43	0.86	1.29	1.71	2.14	2.57	3.00	3.43	3.86	4.28	6.43	8.57	10.71
40	0.24	0.49	0.98	1.47	1.96	2.45	2.94	3.43	3.92	4.41	4.90	7.34	9.79	12.24
45	0.28	0.55	1.10	1.65	2.20	2.75	3.30	3.86	4.41	4.96	5.51	8.26	11.02	13.77
50	0.31	0.61	1.22	1.84	2.45	3.06	3.67	4.28	4.90	5.51	6.12	9.18	12.24	15.30

DESIGN DATA



Pipe Deflection

IPEX BlazeMaster fire sprinkler piping is inherently ductile allowing it to be deflected, within permissible limits, around or away from objects during installation, which can reduce installation time. This ductility allows for greater freedom of design and lower installed cost. The maximum installed deflections for BlazeMaster piping are as follows:

Maximum Installed Deflections (One End Restrained)

Formula: $d = 0.329 \frac{L^2}{D}$

Where: d = deflection in inches
 L = length in feet
 D = average outside diameter in inches (ref. Pg. 7)



Example L = 10 ft.
 D = 2.375" (for 2" pipe)
 $d = 0.329 \times \frac{10^2}{2.375}$
 $= 0.329 \times \frac{100}{2.375}$
 $= 13.90$

Pipe Size inches	Pipe Length in Feet													
	2	5	7	10	12	15	17	20	25	30	35	40	45	50
	Permissible Bending Deflections SDR 13.5 (73°F) in Inches													
¾	1.30	7.80	15.40	31.30	45.10	70.50	90.60	125.40	195.90	282.10	383.90			
1	1.00	6.30	12.30	25.00	36.00	56.30	72.30	100.10	156.40	225.20	306.60	400.40		
1¼	0.80	5.00	9.70	19.80	28.50	44.60	57.30	79.30	123.90	178.40	242.80	317.20	401.40	
1½	0.70	4.30	8.50	17.30	24.90	39.00	50.10	69.30	108.20	155.90	212.20	277.10	350.70	433.00
2	0.60	3.50	6.80	13.90	20.00	31.20	40.00	55.40	86.60	124.70	169.70	221.70	280.60	346.40
2½	0.50	2.90	5.60	11.40	16.50	25.80	33.10	45.80	71.50	103.00	140.20	183.10	231.80	286.20
3	0.40	2.40	4.60	9.40	13.50	21.20	27.20	37.60	58.80	84.60	115.20	150.40	190.40	235.10

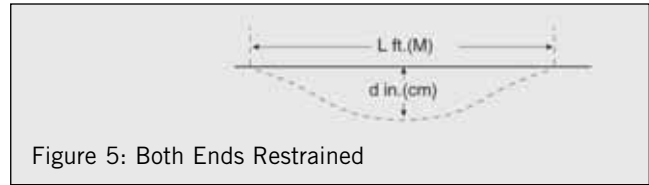
Formula: $d = 228.472 \frac{L^2}{D}$

Where: d = deflection in cm
 L = length in meters
 D = average outside diameter in mm (ref. Pg. 7)

Example L = 5 m.
 D = 60.3 mm (for 50 mm pipe)
 $d = 228.472 \times \frac{5^2}{60.3}$
 $= 228.472 \times \frac{25}{60.3}$
 $= 94.70$

Pipe Size mm	Pipe Length in Meters													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Permissible Bending Deflections SDR 13.5 (23°C) in cm													
20	8.60	34.30	77.10	137.10	214.20	308.40	419.80	548.30	694.00	856.70	1,036.70			
25	6.80	27.40	61.60	109.50	171.00	246.30	335.20	437.80	554.10	684.10	827.80	985.10		
32	5.40	21.70	48.80	86.70	135.50	195.10	265.50	346.80	439.00	541.90	655.70	780.40	915.80	
40	4.70	18.90	42.60	75.80	118.40	170.40	232.00	303.00	383.50	473.50	572.90	681.80	800.20	928.00
50	3.80	15.20	34.10	60.60	94.70	136.40	185.60	242.40	306.80	378.80	458.30	545.40	640.10	742.40
65	3.10	12.50	28.20	50.10	78.20	112.60	153.30	200.30	253.40	312.90	378.60	450.60	528.80	613.30
80	2.60	10.30	23.10	41.10	64.30	92.50	125.90	164.50	208.20	257.00	311.00	370.10	434.40	503.80

Maximum Installed Deflections (Both Ends Restrained)



Formula: $d = 0.0823 \frac{L^2}{D}$

Where: d = deflection in inches
 L = length in feet
 D = average outside diameter in inches (ref. Pg. 7)

Example L = 10 ft.
 D = 2.375" (for 2" pipe)
 $d = 0.0823 \times \frac{10^2}{2.375}$
 $= 0.0823 \times \frac{100}{2.375}$
 $= 3.50$

Pipe Size inches	Pipe Length in Feet													
	2	5	7	10	12	15	17	20	25	30	35	40	45	50
	Permissible Bending Deflections SDR 13.5 (73°F) in Inches													
¾	0.30	2.00	3.80	7.80	11.30	17.60	22.60	31.10	49.00	70.50	96.00	125.40	158.70	195.90
1	0.30	1.60	3.10	6.30	9.00	14.10	18.10	25.00	39.10	56.30	76.60	100.10	126.70	156.40
1¼	0.20	1.20	2.40	5.00	7.10	11.20	14.30	19.80	31.00	44.60	60.70	79.30	100.40	123.90
1½	0.20	1.10	2.10	4.30	6.20	9.70	12.50	17.30	37.10	39.00	53.00	69.30	87.70	108.20
2	0.10	0.90	1.70	3.50	5.00	7.80	10.00	13.90	21.60	31.20	42.40	55.40	70.10	86.60
2½	0.10	0.70	1.40	2.90	4.10	6.40	8.30	11.40	17.90	25.80	35.10	45.80	57.90	71.50
3	0.10	0.60	1.20	2.40	3.40	5.30	6.80	9.40	14.70	21.20	28.80	37.60	47.60	58.80

Formula: $d = 57.1528 \frac{L^2}{D}$

Where: d = deflection in cm
 L = length in meters
 D = average outside diameter in mm (ref. Pg. 7)

Example L = 5 m.
 D = 60.3 mm (for 50 mm pipe)
 $d = 57.1528 \times \frac{5^2}{60.3}$
 $= 57.1528 \times \frac{25}{60.3}$
 $= 23.70$

Pipe Size mm	Pipe Length in Meters													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Permissible Bending Deflections SDR 13.5 (23°C) in cm													
20	2.10	8.60	19.30	34.20	53.50	77.10	104.90	137.00	173.40	214.10	259.00	308.20	361.80	419.50
25	1.70	6.80	15.40	27.40	42.80	61.60	83.80	109.50	138.60	171.10	207.10	246.40	289.20	335.40
32	1.40	5.40	12.20	21.70	33.90	48.80	66.40	86.70	109.70	135.40	163.90	195.00	228.90	265.40
40	1.20	4.70	10.60	18.90	29.60	42.60	58.00	75.70	95.80	118.30	143.20	170.40	200.00	231.90
50	0.90	3.80	8.50	15.20	23.70	34.10	46.40	60.70	76.80	94.80	114.70	136.50	160.20	185.80
65	0.80	3.10	7.00	12.50	19.60	28.20	38.40	50.10	63.40	78.30	94.70	112.70	132.30	153.50
80	0.60	2.60	5.80	10.30	16.10	23.10	31.50	41.10	52.10	64.30	77.80	92.60	108.60	126.00

DESIGN DATA

Chemical Compatibility

CPVC domestic water, fire sprinkler, and industrial piping systems have been used successfully for more than 40 years in new construction, re-pipe and repair. CPVC products are ideally suited for these applications due to their outstanding corrosion resistance. Occasionally, however, CPVC and PVC can be damaged by contact with chemicals found in some construction products (and site preparations). Reasonable care needs to be taken to insure that products coming into contact with CPVC systems are chemically compatible. IPEX recommends that chemical compatibility with CPVC be confirmed with the manufacturer of the product in contact with CPVC piping systems. (Refer to the Chemical Compatibility Section under Products & Services at www.blazemaster.com for additional information on compatibility.)

A Note on Microbiologically Influenced Corrosion (MIC)

In areas where water supplies are known to have contributed to MIC, NFPA requires metallic fire sprinkler system water supplies to be tested and appropriately treated. Reference Section 9-1.5 of NFPA 13 (1999 Edition). This testing and treatment is not required when using IPEX BlazeMaster CPVC products. BlazeMaster CPVC is not susceptible to MIC because:

1. CPVC surfaces discourage the adherence of the bacteria associated with MIC. In metallic systems, colonies form around the bacteria that entrap organic acids against the wall, causing the pitting which is common with MIC.
2. As the bacteria associated with MIC cannot adhere to the inner surface of CPVC, the bacteria will not propagate as rapidly.
3. The organic acids produced by the MIC bacteria promote the oxidation of metals but do not affect CPVC. In fact, the compounds that comprise BlazeMaster pipe and fittings are known to be unaffected in extreme acid environments far more severe than those environments associated with MIC.

Note 1: Metal components within non-metallic fire sprinkler systems are not immune to MIC.

Note 2: MIC has not been evaluated by UL for this product.

Freeze Protection

Freeze protection can be provided in a variety of methods including system design, insulation and antifreeze.

Batt Insulation

Many jurisdictions recommend the use of batt insulation for freeze protection in place of antifreeze solutions. These jurisdictions typically publish batt insulation guidelines that provide the minimum thickness of insulation to be utilized. Reference NFPA 13D Section A-4-3.1 (1999 Edition) for additional recommendations.

Antifreeze Solutions

Glycerin antifreeze solutions are acceptable for use with IPEX BlazeMaster piping. Glycol shall not be used with IPEX BlazeMaster pipe and fittings. Always install antifreeze systems per the NFPA guidelines. Refer to Section 4-5.2 of NFPA 13 (1999 Edition).

The following considerations should be incorporated into the system design when providing for freeze protection:

- Always follow the manufacturers' installation instructions provided by IPEX. This is especially important with regard to the torque requirements for sprinkler installation, the specific type and use of Teflon® tape, and the specific type and use of a thread paste sealant.
- Use only high quality Teflon® tape or a thread paste sealant recommended by IPEX. Never combine both Teflon® tape and thread paste sealants.
- Follow NFPA 13 Section 4-5.3.2 (1999 Edition) requirement regarding the installation and use of expansion chambers when backflow prevention devices are installed with steel, copper and CPVC. NOTE: Most existing backflow prevention devices do not allow entrapped pressure to be relieved.
- Follow NFPA 13 Section A-4-5.1 (1999 Edition) recommendation of not exceeding a maximum 40-gallon antifreeze volume for steel, copper and CPVC systems.
- Consider the use of glycerin and water solution antifreeze loops rather than the practice of installing glycerin and water solutions into the entire sprinkler system.

Estimating Antifreeze Solution Requirements

Fitting Size		Gallons per Foot of Pipe	Liters per Meter of Pipe
inches	mm		
3/4	19.05	0.031	0.036
1	25.40	0.049	0.057
1 1/4	31.75	0.079	0.091
1 1/2	38.10	0.104	0.120
2	50.80	0.164	0.189
2 1/2	63.50	0.240	0.277
3	76.20	0.355	0.410

Painting

The UL and ULC Listing does not cover painted CPVC pipe and fittings.

When painting of the system is permitted, water-based acrylic latex paint is the preferred and recommended paint to use on BlazeMaster CPVC pipe and fittings. Oil or solvent-based paints may be chemically incompatible.

Certain types of oil or solvent-based paints may, however, be used provided that it is a light coating that dries quickly. These paints should not be allowed to puddle or pool on the surface. Application of solvent-based paints must be individually reviewed as there are certain types of paints and stains that contain drying oils and should not be used at all on CPVC. (Refer to the Chemical Compatibility Section under Product & Services at www.blazemaster.com for additional information on compatibility.)



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SECTION FIVE: HANDLING AND INSTALLATION

IPEX BlazeMaster CPVC is a tough, corrosion resistant material, but does not have the mechanical strength of steel. Reasonable care must be exercised in handling BlazeMaster pipe and fittings. They must not be dropped or have objects dropped on them. If improper handling results in scratches, splits, or gouges, the damaged section shall be cut out and discarded.

IPEX BlazeMaster pipe must be covered with a non-transparent material when stored out of doors for extended periods of time. Brief exposure to direct sunlight on the job site may result in color fade but will not affect physical properties. BlazeMaster fittings should be stored in their original containers to keep them free from dirt and reduce the possibility of damage. Caution should be taken not to overstack boxes of BlazeMaster fittings in extreme temperature environments (>150°F).

Underground Water Pressure Service

Both pipe and fittings may be used in underground water pressure service installations per the following requirements:

1. ASTM D 2774, Standard Recommended Practice for Underground Installation of Thermoplastic Pressure Piping,
2. ASTM F 645, Standard Guide for Selection, Design and Installation of Thermoplastic Water Pressure Piping Systems, and
3. The system shall be installed per the requirements of NFPA 24.
4. The BlazeMaster CPVC sprinkler pipe and fittings shall be installed per the manufacturer's installation instructions and this design manual.

Installation

Thrust Blocking

If thrust blocks are utilized they should be designed per NFPA 24, Section 8-6-2 (1995 Edition).

Note: BlazeMaster fire sprinkler systems utilize a solvent cement joining method. As such, thrust blocks are not required with BlazeMaster CPVC pipe and fittings in underground water pressure service. Reference NFPA 24, Section A-8-6.1 (1995 Edition).

Trenching

The trench should be of adequate width to allow convenient installation, while at the same time being as narrow as possible. Minimum trench widths may be utilized by joining pipe outside of the trench and lowering it into the trench after adequate joint strength has been achieved. (NOTE: Refer to the page 15 in this design manual for recommended set and cure time for solvent cement joints). Trench widths will have to be wider where pipe is joined in the trench or where thermal expansion and contraction is a factor. See section titled "Snaking of Pipe".

- Water filled pipe should be buried at least 12" (305 mm) below the maximum expected frost line.
- It is recommended that BlazeMaster piping be run within a metal or concrete casing when it is installed beneath surfaces that are subject to heavy-weight or constant traffic such as roadways and railroad tracks.

The trench bottom should be continuous, relatively smooth and free of rocks. Where ledge rock, hardpan or boulders are encountered, it is necessary to protect the pipe from damage. Use a minimum of 4" (102 mm) of clean soil or sand. Crushed stone or other materials may have a negative impact on the performance of the pipe.

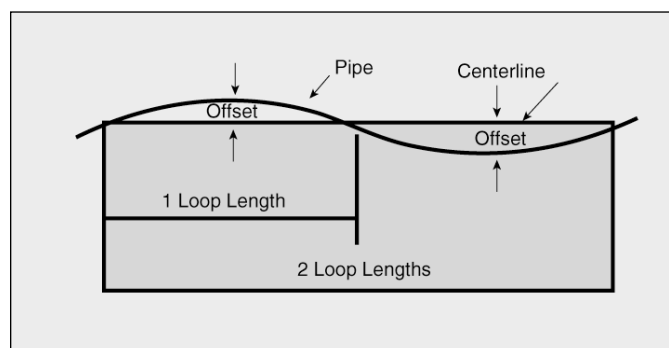
Sufficient cover must be maintained to keep external stress levels below acceptable design stress. Reliability and safety of service is of major importance in determining minimum cover. Local, state and national codes may also govern.

Snaking of Pipe

After BlazeMaster CPVC pipe has been solvent welded, it is advisable to snake the pipe according to the below recommendations beside the trench during its required curing time. BE ESPECIALLY CAREFUL NOT TO APPLY ANY STRESS THAT WILL DISTURB THE UNDRIED JOINT. This snaking is necessary in order to allow for any anticipated thermal movement that could take place in the newly joined pipeline.

Snaking is particularly necessary on the lengths that have been solvent welded during the late afternoon on a hot summer's day, because their drying time will extend through the cool of the night when thermal contraction of the pipe could stress the joints to the point of pull out. This snaking is also especially necessary with pipe that is laid in its trench (necessitating wider trenches than recommended) and is back-filled with cool earth before the joints are thoroughly dry.

Figure 6: Snaking of Pipe



Backfilling

Note: Underground pipe shall be thoroughly inspected and tested for leaks prior to backfilling. Backfill material should be placed over pipe sections only, leaving the joints exposed during testing.

Ideally, backfilling should only be done early in the morning during hot weather when the line is fully contracted and there is no chance of insufficiently dried joints being subjected to contraction stresses.

The pipe should be uniformly and continuously supported over its entire length on firm, stable material. Blocking should not be used to change pipe grade or to intermittently support pipe across excavated sections.

Loop Offset in Inches for Contraction:

**Maximum Temperature Variation, °F,
Between Time of Solvent Welding and Final Use**

Degrees	Loop Length		
	20 Feet	50 Feet	100 Feet
10°	3	7	13
20°	4	9	18
30°	5	11	22
40°	5	13	26
50°	6	14	29
60°	6	16	32
70°	7	17	35
80°	7	18	37
90°	8	19	40
100°	8	20	42

Loop Offset in mm for Contraction:

**Maximum Temperature Variation, °C,
Between Time of Solvent Welding and Final Use**

Degrees	Loop Length		
	65.6 Meters	164 Meters	328 Meters
(12°)	76	178	330
(7°)	102	229	457
(1°)	127	279	559
4°	127	330	660
10°	152	356	737
16°	152	406	813
21°	178	432	889
27°	178	457	940
32°	203	483	1016
38°	203	508	1067

Pipe is installed in a wide range of sub-soils. These soils should not only be stable but applied in such a manner to physically shield the pipe from damage. Attention should be given to local pipe laying experience that may indicate particular pipe bedding problems.

Backfill materials free of rocks with a particle size of ½" (12.7 mm) or less should be used to surround the pipe with 6" (152 mm) to 8" (203 mm) of cover. It should be placed in layers. Each soil layer should be sufficiently compacted to uniformly develop lateral passive soil forces during the backfill operation. It may be advisable to have the pipe under hydraulic pressure, 15 to 25 psi (103 – 172 kPa) during the backfilling.

Vibratory methods are preferred when compacting sand or gravel. Best results are obtained when the soils are in a nearly saturated condition. Where water flooding is used, the initial backfill should be sufficient to insure complete coverage of the pipe. Additional material should not be added until the water flooded backfill is firm enough to walk on. Care should be taken to avoid floating the pipe.

Sand and gravel containing a significant proportion on fine-grained material, such as silt and clay, should be compacted by hand or, preferably by mechanical tamper.

The remainder of the backfill should be placed and spread in approximately uniform layers in such a manner to fill the trench completely so that there will be no unfilled spaces under or about the rocks or lumps of earth in the backfill. Large or sharp rocks, frozen clods and other debris greater than 4" (102 mm) in diameter should be removed. Rolling equipment or heavy tampers should only be used to consolidate the final backfill.

The pipe should be sleeved with a compatible sleeving where it penetrates the slab.

Outdoor Installations

IPEX BlazeMaster pipe and fittings are not listed for exposed, outdoor applications.

Joining IPEX BlazeMaster Pipe and Fittings with Red One Step Solvent Cement

Note: BlazeMaster BM-5 One Step Cement requires no cleaner or primer. Refer to individual manufacturers' installation instructions.

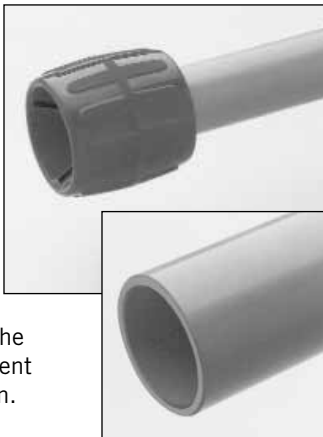
Cutting

IPEX BlazeMaster pipe can be easily cut with a ratchet cutter (except at temperatures below 10°C (50°F)), a wheel-type plastic tubing cutter, a power saw or a fine toothed saw. To ensure the pipe is cut square, a miter box is recommended when using a saw. A square cut provides the surface of the pipe with maximum bonding area. If any indication of damage or cracking is evident at the pipe end, cut off at least 50.8 mm (2") beyond any visible crack.



Deburring

Burrs and filings can prevent proper contact between pipe and fitting during assembly, and must be removed from the outside and the inside of the pipe. A chamfering tool or a file is suitable for this purpose. A slight bevel shall be placed at the end of the pipe to ease entry of the pipe into the socket and minimize the chances of wiping solvent cement from the fitting during insertion.



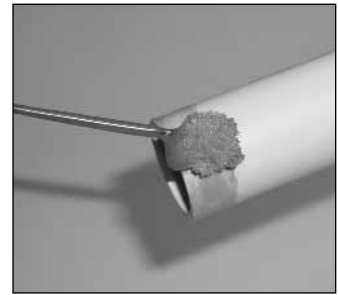
Fitting Preparation

Using a clean, dry rag, wipe loose dirt and moisture from the fitting socket and pipe end. Moisture can slow the cure time and at this stage of assembly, excessive water can reduce joint strength. Check the dry fit of the pipe and fitting. The pipe should enter the fitting socket easily $\frac{1}{4}$ to $\frac{3}{4}$ of the way. At this stage, the pipe should not bottom out in the socket.

Solvent Cement Application

Joining surfaces shall be penetrated and softened. Cement shall be applied (worked into pipe) with an applicator half the nominal size of the pipe diameter. Apply a heavy, even coat of cement to the outside pipe end. Apply a medium coat to the fitting socket. Pipe sizes $1\frac{1}{4}$ " (32 mm) and above shall always receive a second cement application on the pipe end.

(Apply cement on the pipe end, in the fitting socket, and on the pipe again.) Only use solvent cements that have been specifically investigated and tested for use with BlazeMaster CPVC systems and approved by the pipe and fitting manufacturer. Too much cement can cause clogged waterways. Do not allow excess cement to puddle in the pipe and fitting assembly.

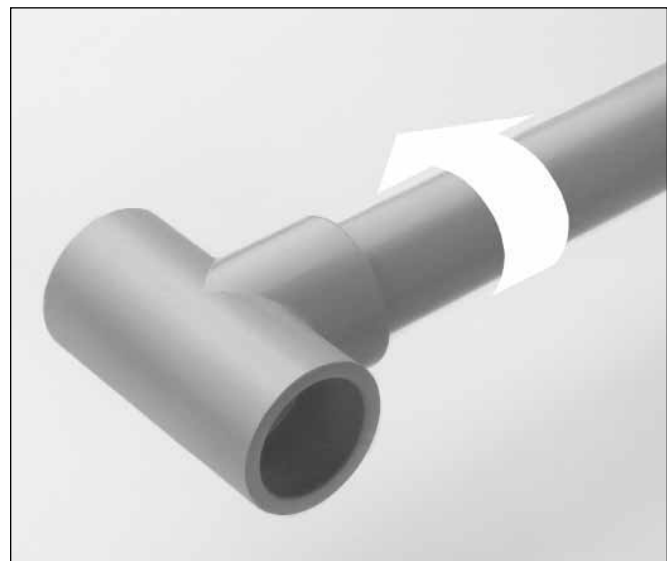


Special care shall be exercised when assembling BlazeMaster systems in extremely low temperatures (below 4°C (40°F)) or extremely high temperatures (above 38°C (100°F)). Extra set time shall be allowed in colder temperatures. When cementing pipe and fittings in extremely cold temperatures, make certain that the cement has not "gelled". Gelled cement must be discarded. In extremely hot temperatures, make sure both surfaces to be joined are still wet with cement when putting them together.



Assembly

After applying cement, immediately insert the pipe into the fitting socket, while rotating the pipe one-quarter turn. Properly align the fitting for the installation at this time. Pipe must bottom to the stop. Hold the assembly for 10 to 15 seconds to ensure initial bonding. A bead of cement should be evident around the pipe and fitting juncture. If this bead is not continuous around the socket shoulder, it may indicate that insufficient cement was applied.



If insufficient cement is applied, the fitting must be cut out and discarded.

Cement in excess of the bead can be wiped off with a rag. Care shall be exercised when installing sprinkler heads. Sprinkler head fittings shall be allowed to cure for a minimum of 30 minutes prior to installing the sprinkler head. When installing sprinkler heads, be sure to anchor or hold the pipe drop securely to avoid rotating the pipe in previously cemented connections. Previously cemented fittings shall also be permitted to cure for a minimum of 30 minutes.

Warning: Sprinkler heads shall be installed only after all the CPVC pipe and fittings, including the sprinkler head adapters, are solvent welded to the piping and allowed to cure for a minimum of 30 minutes. Sprinkler head fittings should be visually inspected and probed with a wooden dowel to ensure that the water way and threads are clear of any excess cement. Once the installation is complete and cured per Table I, II or III, the system shall be hydrostatically tested. Sprinklers shall not be installed in the fittings prior to the fittings being cemented in place.

Note: Safety and Health Precautions. Prior to using CPVC solvent cements, review and follow all precautions found on the container labels, material safety data sheet, and Standard Practice for Safe Handling ASTM F 402.

Set and Cure Times

Solvent cement set and cure times are a function of pipe size, temperature, relative humidity, and tightness of fit. Curing time is faster for drier environments, smaller pipe sizes, higher temperatures and tighter fits. The assembly must be allowed to set, without any stress on the joint, for 1 to 5 minutes, depending on pipe size and temperature. Following initial set period, the assembly can be handled carefully, avoiding significant stresses to the joint. Refer to the following tables for minimum cure times prior to pressure testing.



TABLE I 1552 kPa (225 psi) Test Pressure (maximum) Ambient Temperature During Cure Period

Pipe Size		Temperature		
inches	mm	16°C to 49°C (60°F to 120°F)	≥ 4.4°C (≥ 40°F)	≥17.8°C (≥ 0°F)
3/4	20	1 hr	4 hrs	48 hrs
1	25	1½ hrs	4 hrs	48 hrs
1¼	32 & 40	3 hrs	32 hrs	10 days
2	50	8 hrs	48 hrs	Note 1
2½ & 3	65 & 80	24 hrs	96 hrs	Note 1

TABLE II 1379 kPa (200 psi) Test Pressure (maximum) Ambient Temperature During Cure Period

Pipe Size		Temperature		
inches	mm	16°C to 49°C (60°F to 120°F)	≥ 4.4°C (≥ 40°F)	≥17.8°C (≥ 0°F)
3/4	20	45 mins	1½ hrs	24 hrs
1	25	45 mins	1½ hrs	24 hrs
1¼	32 & 40	1½ hrs	16 hrs	120 hrs
2	50	6 hrs	36 hr	Note 1
2½ & 3	65 & 80	8 hrs	72 hrs	Note 1

TABLE III 690 kPa (100 psi) Test Pressure (maximum) Ambient Temperature During Cure Period

Pipe Size		Temperature		
inches	mm	16°C to 49°C (60°F to 120°F)	≥ 4.4°C (≥ 40°F)	≥17.8°C (≥ 0°F)
3/4	20	15 mins	15 mins	30 mins
1	25	15 mins	30 mins	30 mins
1¼	32 & 40	15 mins	30 mins	2 hrs

Note: For these sizes, the solvent cement can be applied at temperatures below -17.8°C (0°F), however, the sprinkler system temperature must be raised to a temperature of 0°C (32°F) or above and allowed to cure per the above recommendations prior to pressure testing.

Cut-in procedures for system modification or repairs

Prior to making system cut-ins on existing systems, care should be used to review proper joining procedures and to FOLLOW CUT-IN CURE SCHEDULES to ensure the highest system integrity. Several methods can be utilized to tie into an existing system using a socket style tee fitting in combination with the use of socket couplings, unions, grooved coupling adapters, and flanges. Regardless of the method used, the following points must be followed to ensure the highest integrity:

- Using proper tools, the cut-in should be made on the smallest diameter pipe section (that is capable of adequately supplying the system changes) in close proximity to the modification being made. This approach will expedite cure times prior to pressure testing.
- The cut-in connection to the existing system should be made first, prior to proceeding with additional work.
- Existing lines must be drained adequately prior to solvent cementing. Use a Drain Vac unit to be sure all water is removed from the system (moisture can slow the cure time and reduce joint strength).
- Carefully review and follow manufacturer's solvent cementing procedures for proper joining techniques prior to commencing with cut-in (pipe must be cut square to proper length, deburred, beveled and dry to ensure proper insertion depth and highest integrity).
- Carefully measure and cut pipe to proper length to ensure complete insertion during assembly (check the dry fit of the components being joined).
- Note: During assembly of the Cut-In tee (and other components) it is important to make the ¼ turn when inserting the pipe into the fitting per the manufacturer's assembly instruction, particularly on 1½" pipe sizes and larger. This may require the use of several components assembled in combination with the cut-in tee to create a short spool piece assembly. This can be accomplished by using socket unions, flanges, or grooved coupling adapters that will ensure that a ¼ turn can be obtained on all pipe connections being joined.
- Prior to applying solvent cement use a clean *dry* rag to wipe moisture and dirt from the fitting socket and the pipe end (the presence of moisture on the joining surfaces will reduce joint integrity).
- Use a new can of cement when making cut-in connections (verify expiration dates stamped on can prior to use).
- After all work is completed, the cut-in *joints must be allowed to cure properly prior to pressure testing* as follows:

CUT-INS			
Minimum Cure Prior to Pressure Testing			
Pipe Size	Ambient Temperature During Cure		
	16°C to 49°C (60°F to 120°F)	≥ 4.4°C (≥ 40°F)	≥ 17.8°C (≥ 0°F)
¾"	1 hour	4 hours	48 hours
1"	1½ hours	4 hours	48 hours
1¼" & 1½"	3 hours	32 hours	10 days
2"	8 hours	48 hours	*
2½" & 3"	24 hours	96 hours	*

** Solvent cement can be applied at temperatures below 40°F for 2" sizes and larger, however the temperature of the system must be raised to 40°F or higher and allowed to cure per the above recommendations prior to pressure testing. When bringing cement, pipe or fittings in from the outside, be certain they are brought up to room temperature before using the 60°F to 120°F cure schedule.*

- After work is completed and Cut-In cure times are met, inspect work for proper alignment and hanger placement prior to pressure testing.
- *After Cut-In cure times are met*, the system must be *slowly* filled with water and the air bled from the furthest and highest sprinkler heads before test pressure is applied (refer to manufacturer's installation instructions regarding Hydrostatic Testing).
- After cut-in cure times are met and the air is bled from the system, it is recommended that the portion of the sprinkler system containing the cut-in tee be pressure tested. Prior to pressure testing, the system must be sectioned off to its smallest area using floor valves etc. to isolate the cut-in area. It is further recommended that the test pressure applied should not exceed 50 psi over the system pressure. This approach will minimize the potential for water damage should a leak occur.

Pressure Testing

Once an installation is completed and cured, per the previous recommendations, the system should be pressure tested at 1379 kPa (200 psi), Table II, for 2 hours (or at 345 kPa (50 psi) in excess of the maximum pressure, Table I, when the maximum pressure to be maintained in the system is in excess of 1034 kPa (150 psi) in accordance with the requirements established by NFPA Standard 13, Section 10-2.2.1 (1999 Edition). Sprinkler systems in one- and two-family dwellings and mobile homes may be tested at line pressure, Table III in accordance with the requirements established by NFPA 13D, Section 1-5.4 (1999 Edition). When pressure testing, the sprinkler system shall be slowly filled with water and the air bled from the highest and farthest sprinkler heads before pressure testing is applied. Air must be removed from piping systems (plastic or metal) to prevent it from being locked in the system when pressure is applied. Entrapped air can generate excessive surge pressures that are potentially damaging, regardless of the piping materials used. Air or compressed gas should never be used for pressure testing. If a leak is found, the fitting must be cut out and discarded. A new section can be installed using couplings or a union. Unions should be used in accessible areas only.

Estimating One-Step Solvent Cement Requirements

The following guidelines are provided to allow estimation of one-step solvent cement quantities needed.

Fitting Size		Number of Joints Per Quart	Number of Joints Per Liter
inches	mm		
¾	19.05	270	285
1	25.40	180	190
1¼	31.75	130	137
1½	38.10	100	106
2	50.80	70	74
2½	63.50	50	53
3	76.20	40	42

Hangers and Supports

Because IPEX BlazeMaster pipe is rigid, it requires fewer supports than flexible plastic systems. The support spacing is shown in the following table.

Most hangers designed for metal pipe are suitable for BlazeMaster pipe. Do not use undersized hangers. Hangers with sufficient load bearing surface shall be selected based on pipe size, i.e., 40 mm hangers for 40 mm pipe. The hanger shall not have rough or sharp edges that come in contact with the pipe. The pipe hangers must comply with the requirements in NFPA 13, 13R, and 13D. For Quick Response upright sprinkler heads, rigid hangers secured to the ceiling shall be used.

Nominal Size		Maximum Support Spacing	
inches	mm	feet	meters
¾	19.05	5½	1.67
1	25.40	6	1.83
1¼	31.75	6½	1.98
1½	38.10	7	2.13
2	50.80	8	2.43
2½	63.50	9	2.74
3	76.20	10	3.05

When a sprinkler head activates, a significant reactive force can be exerted on the pipe. With a pendent head, this reactive force can cause the pipe to lift vertically if it is not properly secured, especially if the sprinkler drop is from small diameter pipe. The closest hanger shall brace the pipe against vertical lift-up. See Tables A & B.

For exposed installations in accordance with the UL and ULC Listing, Listed support devices shall be used which mount the BlazeMaster CPVC piping directly to the ceiling or sidewall.

TABLE A Maximum Support Spacing Distance In Line Sprinkler Head Drop Tee

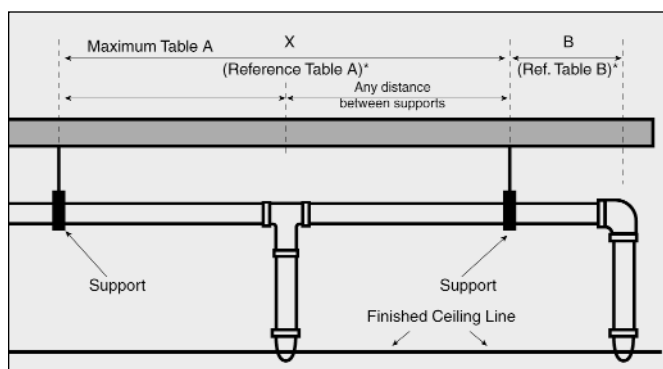
Nominal Pipe Size		Less than 690 kPa (100psi)		More than 690 kPa (100 psi)	
inches	mm	feet	meters	feet	meters
¾	19.05	4	1.22	3	0.91
1	25.40	5	1.52	4	1.22
1¼	31.75	6	1.83	5	1.52
1½-3	38.10 - 76.20	7	2.13	7	2.13

TABLE B Maximum Support Spacing Distance End Line Sprinkler Head Drop Elbow

Nominal Pipe Size		Less than 690 kPa (100psi)		More than 690 kPa (100 psi)	
inches	mm	inches	mm	inches	mm
3/4	19.05	9	228.60	6	152.40
1	25.40	12	304.80	9	228.60
1 1/4	31.75	16	406.40	12	304.80
1 1/2-3	38.10 - 76.20	24	609.60	12	304.80

The closest hanger shall brace the pipe against vertical lift-up. Any of a number of techniques can be used to brace the pipe. Four acceptable approaches would be to use a standard band hanger positioning the threaded support rod to 1.588 mm (1/16") above the pipe, a split-ring hanger, a wrap-around U hanger, or a special escutcheon which prevents upward movement of the sprinkler through the ceiling.

Figure 7: Support Spacing Drop Elbow and Drop Tee



Penetration of Studs and Joists

Wooden Studs and Joists

It is acceptable to cut holes in wood studs for support. The holes should be oversized to allow for movement.

Metal Studs

IPEX BlazeMaster pipe and fittings should be protected from sharp edges when passing through metal studs.

Transition to Other Materials

Support

Additional support should be added at the metal side of a IPEX BlazeMaster CPVC-metal transition to support the weight of the metal system.

Threaded Connections

IPEX BlazeMaster CPVC female threaded adapters or flanges are listed for connecting a BlazeMaster fire sprinkler system to other materials, valves, and appurtenances.

A thread sealant shall be used in making threaded connections. TFE (Teflon®) thread tape is the recommended sealant. Some thread sealants other than TFE thread tape contain solvents or other materials that may be damaging to CPVC. Contact your authorized IPEX BlazeMaster distributor or IPEX Representative for approved thread sealants. Use of thread sealants other than those approved by IPEX will void the warranty on the IPEX BlazeMaster system.

Care shall be exercised when transitioning between IPEX BlazeMaster pipe and fittings and metal. Care must be taken to avoid over-torquing. Refer to section on instructions for torque requirements.

The following is the recommended method of installation to ensure a sound connection.

- Begin by applying 2 to 3 wraps of TFE (Teflon®) thread tape.
- Tighten the sprinkler head into the adapter taking care not to cross-thread the fitting. (Recommended torque values 15-25 ft/lbs)
- Two to three turns beyond finger-tight is all that is required to make a sound plastic threaded connection.

CAUTION: Over-tightening will damage both the pipe and the fitting.

Flanged Connections

Flange Make-Up: Once a flange is joined to pipe, the method for joining two flanges is as follows:

- Piping runs joined to the flanges must be installed in a straight line position to the flange to avoid stress at the flange due to misalignment. Piping must also be secured and supported to prevent lateral movement that can create stress and damage the flange.
- With gasket in place, align the bolt holes of the mating flanges by rotating the ring into position. (Consideration should be given to alignment of One-Piece Flange prior to joining with pipe.)
- Insert all bolts, washers (two standard flat washers per bolt), and nuts.
- Make sure the faces of the mating surfaces are flush against gasket prior to bolting down the flanges.
- Tighten the nuts by hand until they are snug. Establish uniform pressure over the flange face by tightening the bolts in 5 ft. lb. (6.8 M Kg) increments according to the sequence shown in Figure 8: Bolt Tightening Sequence following a 180° opposing sequence.

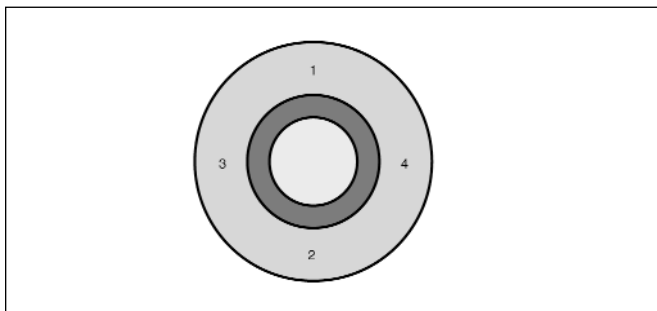
- Care must be taken to avoid “bending” the flange when joining a flange to a “raised face” flange, or a wafer-style valve. Do not use bolts to bring together improperly mated flanges.

Caution: Over-torquing will damage the flange. Torque given is for dry, non-lubricated bolt, standard washers, neoprene 3.18 mm (1/8²) thick full face gasket. If lubricant (non-petroleum based) is used, torque levels may vary. Actual field conditions may require a variation in these recommendations.

Recommended Bolt Torque

Flange Size		Bolt Diameter		Torque	
inches	mm	inches	mm	ft lbs	M Kg
3/4 - 1 1/2	19.05 - 38.10	1/2	12.70	10 - 15	13.6 - 20.3
2 - 3	50.80 - 76.20	5/8	15.88	20 - 30	27.1 - 40.7

Figure 8: Bolt Tightening Sequence



Grooved Coupling Adapters

The following procedures are recommended for proper assembly of the Grooved Coupling Adapter. READ THESE INSTRUCTIONS CAREFULLY BEFORE BEGINNING INSTALLATION.

- Inspect the fittings and pipe to insure that they are sufficiently free from indentations, projections or roll-marks on the gasket seating areas of the fitting and pipe. The pipe should be squarely cut with any loose scale, paint and/or dirt must be removed from the groove and seating surface. Use a standard grade E*, EPDM compound that is suitable for wet fire sprinkler service. A flexible coupling shall be used with grooved coupling adapters. Caution: Use of rigid style couplings may damage the grooved coupling adapter. Consult the coupling manufacturer for proper selection.

*See manufacturer for temperature ratings.

- Make sure the gasket is clean and free of any cracks, cuts or other defects which may cause leaks. Lubricate the gasket with a vegetable soap-based gasket lubricant. Caution: Use of petroleum based lubricants will damage the gasket and adapter resulting in stress failure of the CPVC adapter. A

gasket/joint lubricant is recommended to prevent pinching the gasket and to assist in seating the gasket during the alignment process. Apply the appropriate lubricant to the gasket lips and exterior surface of the gasket.

- Place the gasket over the metal pipe ends, being sure gasket lip does not overhang the pipe end. Insert the CPVC grooved coupling adapter into the gasket. Make sure that the gasket is centered between the two grooves. No portion of the gasket should extend into the grooves. Caution: Make sure the gasket is not pinched between the pipe and the fitting.
- Place the metal housing over the gasket, making sure the metal housing key is into the grooves on the metal pipe and the CPVC coupling adapter. Insert the bolts and tighten by hand. Tighten the bolts alternately and equally until the bolt pads are touching metal-to-metal. In completing a proper joint, the gasket is also slightly compressed, adding to the strength of the seal from the gasket’s durometer.
- Inspect the joints before and after pressure testing. Look for gaps between the bolt pads and for housing keys that are not inside the grooves.

Penetrating Fire Rated Walls and Partitions

Before penetrating fire rated walls and partitions, consult building codes and authorities having jurisdiction in your area. Several classified through-penetration firestop systems are approved for use with CPVC pipe. Consult IPEX representative for further information. Warning: Some firestop sealants or wrap strips contain solvents or plasticizers that may be damaging to CPVC. Always consult the manufacturer of the firestop material for compatibility with IPEX BlazeMaster CPVC pipe and fittings.

Earthquake Bracing

Since IPEX BlazeMaster CPVC pipe is more ductile than metallic sprinkler pipe, it has a greater capacity to withstand earthquake damage. In areas subject to earthquakes, BlazeMaster fire sprinkler systems shall be designed and braced in accordance with local codes or NFPA 13, Section 6-4 (1999 Edition).

When it is required to earthquake brace BlazeMaster piping, it is important to use fittings, fasteners or clamps that do not have sharp edges or apply excessive compressive forces sufficient to distort the pipe.

Installation Dos and Don'ts

While not a complete list, the following is intended to highlight many of the “Dos” and “Don'ts” addressed in this manual.

DOS

- INSTALL PRODUCT ACCORDING TO THE MANUFACTURER'S INSTALLATION INSTRUCTIONS AND THIS DESIGN MANUAL.
- FOLLOW RECOMMENDED SAFE WORK PRACTICES.
- MAKE CERTAIN THAT THREAD SEALANTS, GASKET LUBRICANTS, OR FIRE STOP MATERIALS ARE COMPATIBLE WITH BLAZEMASTER CPVC PIPE AND FITTINGS.
- USE ONLY LATEX-BASED PAINTS IF PAINTING IS PERMITTED.
- KEEP PIPE AND FITTINGS IN ORIGINAL PACKAGING UNTIL NEEDED.
- COVER PIPE AND FITTINGS WITH AN OPAQUE TARP IF STORED OUT DOORS.
- FOLLOW PROPER HANDLING PROCEDURES.
- USE TOOLS SPECIFICALLY DESIGNED FOR USE WITH PLASTIC PIPE AND FITTINGS.
- USE PROPER SOLVENT CEMENT AND FOLLOW APPLICATION INSTRUCTIONS.
- USE A DROP CLOTH TO PROTECT INTERIOR FINISHES.
- CUT THE PIPE ENDS SQUARE.
- DEBURR AND BEVEL THE PIPE END BEFORE SOLVENT CEMENTING.
- ROTATE THE PIPE ONE-QUARTER TURN WHEN BOTTOMING PIPE IN FITTING SOCKET.
- AVOID PUDDLING OF SOLVENT CEMENT IN FITTINGS AND PIPE.
- FOLLOW THE MANUFACTURER'S RECOMMENDED CURE TIMES PRIOR TO PRESSURE TESTING.
- FILL LINES SLOWLY AND BLEED THE AIR FROM THE SYSTEM PRIOR TO PRESSURE TESTING.
- SUPPORT SPRINKLER HEAD PROPERLY TO PREVENT LIFT UP OF THE HEAD THROUGH THE CEILING WHEN ACTIVATED.
- KEEP THREADED ROD WITHIN 1.588 MM (1/16") OF THE PIPE.
- INSTALL BLAZEMASTER CPVC FIRE SPRINKLER SYSTEMS IN WET SYSTEMS ONLY.
- USE ONLY INSULATION AND/OR GLYCERIN & WATER SOLUTIONS FOR FREEZE PROTECTION.
- ALLOW FOR MOVEMENT DUE TO EXPANSION AND CONTRACTION.
- RENEW YOUR BLAZEMASTER CPVC FIRE SPRINKLER INSTALLATION TRAINING EVERY TWO YEARS.

DON'TS

- DO NOT USE EDIBLE OILS SUCH AS CRISCO® AS A GASKET LUBRICANT.
- DO NOT USE PETROLEUM OR SOLVENT-BASED PAINTS, SEALANTS, LUBRICANTS OR FIRE STOP MATERIALS.
- DO NOT USE ANY GLYCOL-BASED SOLUTIONS AS AN ANTI-FREEZE.
- DO NOT MIX GLYCERIN AND WATER SOLUTION IN CONTAMINATED CONTAINERS.
- DO NOT USE BOTH TEFLON® TAPE AND THREAD SEALANTS SIMULTANEOUSLY.
- DO NOT USE SOLVENT CEMENT THAT EXCEEDS ITS SHELF LIFE OR HAS BECOME DISCOLORED OR GELLED.
- DO NOT ALLOW SOLVENT CEMENT TO PLUG THE SPRINKLER HEAD ORIFICE.
- DO NOT CONNECT RIGID METAL COUPLERS TO BLAZEMASTER CPVC GROOVED ADAPTERS.
- DO NOT THREAD, GROOVE, OR DRILL BLAZEMASTER CPVC PIPE.
- DO NOT USE SOLVENT CEMENT NEAR SOURCES OF HEAT, OPEN FLAME, OR WHEN SMOKING.
- DO NOT PRESSURE TEST UNTIL RECOMMENDED CURE TIMES ARE MET.
- DO NOT USE DULL OR BROKEN CUTTING TOOL BLADES WHEN CUTTING PIPE.
- DO NOT USE BLAZEMASTER CPVC PIPE THAT HAS BEEN STORED OUTDOORS, UNPROTECTED AND IS FADED IN COLOR.
- DO NOT ALLOW THREADED ROD TO COME IN CONTACT WITH THE PIPE.
- DO NOT INSTALL BLAZEMASTER CPVC PIPE IN COLD WEATHER WITHOUT ALLOWING FOR EXPANSION.
- DO NOT INSTALL BLAZEMASTER CPVC PIPE AND FITTINGS IN DRY SYSTEMS.
- DO NOT ALLOW SOLVENT CEMENT TO RUN AND PLUG THE SPRINKLER HEAD ORIFICE.
- DO NOT PRESSURE TEST WITH AIR OR COMPRESSED GAS.

Maintenance

Maintenance of an IPEX BlazeMaster fire sprinkler system shall be in accordance with the Standard for Inspection, Testing and Maintenance of Water Based Extinguishing Systems as defined by NFPA 25.

Warranty Disclaimer.

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SECTION THREE: APPENDICES

APPENDIX A: REFERENCE TABLES AND CONVERSION CHARTS

TABLE A-1 WEIGHTS OF WATER

Units of Volume	Weight	
	pounds	kilograms
1 US Gallon	8.350	3.791
1 Imperial Gallon	10.020	4.549
1 litre	2.210	1.003
1 cubic yard	1,685.610	765.267
1 cubic foot	62.430	28.343
1 cubic inch	0.036	0.016
1 cubic cm	0.002	0.001
1 cubic metre	2,210.000	1,000.000

TABLE A-2 VOLUME CONVERSION

Units of Volume	in ³	ft ³	yd ³	cm ³	m ³	liter	U.S. gal.	Imp. gal.
cubic inch	1	0.00058	-	16.387	-	0.0164	0.0043	0.0036
cubic foot	1728	1	0.0370	28,317.8	0.0283	28.32	7.481	6.229
cubic yard	46,656	27	1	-	0.7646	764.55	201.97	168.8
cubic centimeter	0.0610	-	-	1	-	0.001	0.0003	0.0002
cubic meter	61,023.7	35.31	1.308	-	1	1000	264.17	220.0
liter	61.02	0.0353	0.0013	1000	0.001	1	0.2642	0.22
U.S. gallon	231	0.1337	0.0050	3785.4	0.0038	3.785	1	0.8327
Imp. gallon	277.42	0.1605	0.0059	4546.1	0.0045	4.546	1.201	1

TABLE A-3 TEMPERATURE CONVERSION

Degrees Celsius °C = $\frac{5}{9} (°F - 32)$	Degrees Fahrenheit °F = $\frac{9}{5} °C + 32$
Degrees Kelvin °T = °C + 273.2	Degrees Rankine °R = °F + 459.7

TABLE A-4 LENGTH CONVERSION

Units of Length	in.	ft.	yd.	mile	mm	cm	m	km
inch	1	0.0833	0.0278	-	25.4	2.54	0.0254	-
foot	12	1	0.3333	-	304.8	30.48	0.3048	-
yard	36	3	1	-	914.4	91.44	0.9144	-
mile	-	5280	1760	1	-	-	1609.3	1.609
millimeter	0.0394	0.0033	-	-	1	0.100	0.001	-
centimeter	0.3937	0.0328	0.0109	-	10	1	0.01	-
meter	39.37	3.281	1.094	-	1000	100	1	0.001
kilometer	-	3281	1094	0.6214	-	-	1000	1

(1 micron = 0.001 millimeter)

APPENDIX B: ABBREVIATIONS

AGA	- American Gas Association
ANSI	- American National Standards Institute
API	- American Petroleum Institute
ASME	- American Society of Mechanical Engineers
ASTM	- American Society for Testing and Materials
AWWA	- American Water Works Association
BNQ	- Bureau de Normalization du Quebec
BOCA	- Building Officials and Code Administrators
BS	- British Standards Institution
CPVC	- Chlorinated poly (vinyl chloride) plastic or resin
CS	- Commercial Standard, see Product Standard
CSA	- Canadian Standards Association
DR	- Dimension Ratio
DIN	- German Industrial Norms
FHA	- Federal Housing Administration or Farmers Home Administration
HDB	- Hydrostatic design basis
HDS	- Hydrostatic design stress
IAPD	- International Association of Plastics Distributors
IAPMO	- International Association of Plumbing and Mechanical Officials
IPC	- International Plumbing Code
ISO	- International Standards Organization
JIS	- Japanese Industrial Standards
NSF	- National Sanitation Foundation International
PPI	- Plastics Pipe Institute
PS	- Product Standard when in reference to a specification for plastic pipe and fittings. These specifications are promulgated by the U.S. Department of Commerce and were formerly known as Commercial Standards.
PSI	- Pounds per square inch
PSIG	- Gage pressure in pounds per square inch
PVC	- Poly (vinyl chloride) plastic or resin
RVCM	- Residual Vinyl Chloride Monomer
SCS	- Soil Conservation Service
SDR	- Standard Dimension Ratio
SI	- International System of Units
SPI	- Society of the Plastics Industry, Inc.
UPC	- Uniform Plumbing Code
USASI	- United States of America Standards Institute (formerly American Standards Association)
WOG	- Water, Oil, Gas

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