Approval Standard for Fire Resistant Barriers for use with CPVC Pipe and Fittings in Light Hazard Occupancies

Class Number 1636

November 2003

Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet FM Approvals' stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and

b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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1. INTRODUCTION

1.1 Purpose

1.1.1 This standard states FM Approvals criteria for fire resistant barriers for use with chlorinated polyvinyl chloride (CPVC) pipe and fittings in light hazard occupancies for automatic wet sprinkler fire protection systems.

1.1.2 FM Approvals criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a follow-up program.

1.2 Scope

1.2.1 This standard encompasses the design and performance requirements for fire resistant barriers for use with CPVC pipe and fittings in light hazard occupancies for automatic wet sprinkler fire protection systems. The intent is to determine if specific CPVC compounds/fire resistant barrier combinations are capable of maintaining sprinkler system integrity and performance during a fire.

1.2.2 The evaluation of fire resistant barriers is based on the premise that the barrier would fail, prior to the failure of the attachment fastener. Therefore, the attachment fastener is not considered to be within the scope of this Approval Standard.

1.2.3 Fire resistant barriers are designed to be used in conjunction with CPVC sprinkler pipe and fittings in light hazard occupancies in ¾ in. through 3 in. nominal pipe size.

1.2.4 FM Approvals standards are intended to verify that the product described will meet stated conditions of performance, safety, and quality useful to the ends of property conservation.

1.3 Basis for Requirements

1.3.1 The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions, and/or loss control specialists was also considered.

1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of fire resistant barriers for the purpose of obtaining FM Approval. Fire resistant barriers having characteristics not anticipated by this standard may be Approved if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, fire resistant barriers that meet all of the requirements identified in this standard may not be Approved if other conditions that adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for FM Approval

FM Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1 Examination and tests on production samples shall be performed to evaluate

- the suitability of the product;
- the performance of the product as specified by the manufacturer and required by FM Approvals; and as far as practical,
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facilities and audit of quality control procedures shall be made to evaluate the manufacturer's ability to produce the product which was examined and tested, and the marking procedures used to identify the product. These examinations are repeated as part of FM Approvals' product follow-up program.

1.5 Basis for Continued Approval

Continued Approval is based upon:

- production or availability of the product as currently Approved;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated in the Master/Approval Agreement;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory Facilities and Procedures Audits (F&PAs) conducted as part of FM Approvals product follow-up program.

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals.

1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products Approved under a previous edition shall comply with the new version by the effective date or forfeit Approval.

The effective date of this standard is **December 1, 2003** for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with the American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-97, *"Standard for Use of the International System of Units (SI): The Modern Metric System."* Two units of measurement (liter and bar), outside of, but recognized by SI, are commonly used in international fire protection and are used in this standard.

1.8 Applicable Documents

The latest versions of the following standards, test methods, and practices are referenced in this standard:

ANSI/IEEE/ASTM SI 10-97, *Standard for Use of the International System of Units (SI): The Modern Metric System.*

ASTM A308-99, *Standard Specification for Steel Sheet, Terne (Lead-Tin Alloy) Coated by the Hot-Dip Process*

ASTM A463/A463M-01a, *Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process*

ASTM A653/A653M-01a, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM A792/A792M-01a, *Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process*

ASTM A875/A875M-01a, *Standard Specification for Steel Sheet, Zinc-5% Aluminum Alloy-Coated by the Hot-Dip Process*

ASTM A924/A924M-99, *Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process*

ASTM A929/A929M-01, *Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe*

ASTM D1784-99, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds*

ASTM D3915-99, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Pressure Applications*

ASTM D4216-00, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Related PVC and Chlorinated Poly (Vinyl Chloride) (CPVC) Building Products Compounds*

ASTM D4396-99, *Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings Used in Nonpressure Applications*

ASTM D5260-97, *Standard Classification for Chemical Resistance of Poly (Vinyl Chloride) (PVC) Homopolymer and Copolymer Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds*

ASTM F1970-01, *Standard Specification for Special Engineered Fittings, Appurtenances or Valves for use in Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Systems*

ASTM F437-99, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*

ASTM F438-01, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*

ASTM F439-01, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*

ASTM F441/F441M-99, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80*

ASTM F442/F442M-99, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*

ASTM F493-97, *Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings*

BSR/ASTM D1784-200x, *Specification for Rigid Poly Vinyl Chloride PVC Compounds and Chlorinated Poly Vinyl Chloride CPVC Compounds*

BSR/ASTM D3915-200x, *Specification for Rigid Poly Vinyl Chloride PVC and Chlorinated Poly Vinyl Chloride CPVC Compounds for Plastic Pipe and Fittings used in Pressure Applications*

BSR/ASTM F438-200x, *Specification for Socket-type Chlorinated Poly Vinyl Chloride CPVC Plastic Pipe Fittings, Schedule 40*

BSR/ASTM F439-200x, *Specification for Chlorinated Poly Vinyl Chloride CPVC Plastic Pipe Fittings, Schedule 80*

BSR/ASTM F493-199x, *Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings*

FM Global Property Loss Prevention Data Sheets

International Maritime Organization (IMO), Maritime Safety Committee (MCS)/Circ. 848, *Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems, as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms*

International Standards Organization (ISO), Draft International Standard, ISO/TC21/SC5/WG8, *Gaseous Fire Extinguishing Systems, Part 1: General Requirements*

1.9 Definitions

For purposes of this standard, the following terms apply:

Accepted

This term refers to installations acceptable to the authority enforcing the applicable installation rules. When the authority is FM Global, such locations are termed ‘‘FM Global Accepted.’’ Acceptance is based upon an overall evaluation of the installation. Factors other than the use of Approved equipment impact upon the decision to accept, or not to accept. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere. (Contrast with FM Approved.)

Approved

This term refers to products Approved by FM Approvals. Such products are listed in the *Approval Guide*, a publication of FM Approvals, issued annually, or one of the supplements. All products so listed have been successfully examined by FM Approvals, and their manufacturers have signed and returned an Approval Agreement to FM Approvals. This form obligates the manufacturer to allow re-examination of the product and audit of facilities and procedures at FM Approvals discretion. It further requires the manufacturer not to deviate from the as-Approved configuration of the product without review by and agreement of FM Approvals. Approval is product specific.

Attachment Fastener

The fastener used to connect the fire resistant barriers to the building.

Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings

Pipe and fittings made of chlorinated poly (vinyl chloride) plastic in which the chlorinated poly (vinyl chloride) is in the greatest amount by weight.

FM Approval Mark

The FM Approval Mark is detailed in Appendix B. Its use is mandatory on all components of Approved fire resistant barriers. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

Fire Resistant Barrier

A barrier used to shield chlorinated poly (vinyl chloride) pipe and fittings from direct contact with an open flame.

IMO Cribs

Fire test cribs designed to the International Maritimes Organization (IMO) standards. An IMO crib consists of six 18 in. (455 mm) lengths of trade size nominal 2 in. by 2 in. (50 mm 3 50 mm) kiln dried spruce or fir lumber having a moisture content between 9 and 13 percent. The members are placed in four alternate layers at right angles to one another. The members are to be evenly spaced forming a square structure. The heat release rate of each IMO crib is approximately 300 kW, See Appendix D.

Ignition Source

Apparatus consisting of a 6 in. (152 mm) diameter steel cylinder, filled with 30 ml (0.008 gallons) of heptane. The ignition source apparatus also provides support for the IMO cribs at a height of 12 in. (305 mm) above floor level. See Appendix E.

Sprinkler Pipe

Nominal one inch SDR 13.5 CPVC sprinkler pipe which includes the sprinkler used in each test. This pipe includes a minimum of one bonded joint. This pipe is supplied by a pressure pump used to supply the required flow rate through the sprinkler after actuation of the sprinkler. This pipe is outfitted with a pressure transducer and is capped on the other end.

Thermocouple Attached Pipe

Nominal one inch SDR13.5 CPVC sprinkler pipe to which three thermocouples are attached in accordance with Appendix F. The thermocouple attached pipe is water filled and maintained at a static pressure of 50 psi (345 kPa) throughout the tests.

2. GENERAL INFORMATION

2.1 Product Information

2.1.1 Fire resistant barriers are limited to use with wet sprinkler systems in light hazard occupancies, using FM Approved quick response extended coverage light hazard (QRECLH) and quick response residential sprinklers in accordance with FM Global Property Loss Prevention Data Sheets.

2.1.2 In order to meet the intent of this standard, fire resistant barriers must be examined on a model-by-model, type-by-type, manufacturer-by-manufacturer, and plant-by-plant basis. This is predicated on the basis that identical designs, fabricated in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been observed to perform differently in testing. Sample fire resistant barriers, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

2.2 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to:

Group Manager — Hydraulics
FM Approvals Hydraulics Laboratory
743A Reynolds Road
West Glocester, RI 02814
U.S.A.

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- General assembly drawings and one complete set of manufacturing drawings;
- Materials list(s) and material specifications (such as AISI-SAE 1020 Carbon Steel);
- Anticipated marking format;
- Brochures, sales literature, specification sheets;
- Installation, operation and maintenance procedures; and,
- The number and location of manufacturing facilities.

All documents shall be part of a controlled system and shall identify the manufacturer’s name, document number or other form of reference, title, date of last revision, and revision level. All foreign language documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

Following set-up and authorization of an Approval examination, the manufacturer shall submit samples for examination and testing. Sample requirements are to be determined by FM Approvals following review of the preliminary information. Sample requirements may vary depending on design features, results of prior testing, and/or the scope of the Approval examination. It is the manufacturer's responsibility to submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. In the event that a component feature prevents the use of existing fixtures, the manufacturer shall supply a suitable test fixture to allow for the evaluation of the component.

3. GENERAL REQUIREMENTS

3.1 Approval Limitation

Approval of each fire resistant barrier shall be limited to use with the specific CPVC compound of which the pipe and fittings are made as well as the bonding agents used in the testing. As such, Approval of multiple CPVC compounds and bonding agents, and combinations thereof, shall require a complete test program for each CPVC compound and bonding agent combination.

3.2 Review of Documentation

During the initial investigation and prior to physical testing, the manufacturer's specifications, technical data sheets, and design details shall be reviewed to assess the ease and practicality of installation and use. The product shall be capable of being used within the limits of the Approval investigation.

3.3 Physical or Structural Features

3.3.1 Fire resistant barriers encompassed by this standard shall be designed such that once assembled the barrier cannot be removed with ordinary tools.

3.3.2 Pipe hanger components used to anchor piping to the wall shall be provided by the barrier manufacturer and shall be compatible with CPVC piping products.

3.3.3 Fire resistant barriers submitted for testing shall be true production samples and shall be free of sharp edges, burrs, or other imperfections which might injure the installer or interfere with proper assembly of the barrier.

3.4 Design Requirements

3.4.1 To ensure long term durability, the fire resistant barrier and all support/attachment devices shall be of adequate strength for use in the intended application. Coatings shall withstand the effects of shipping, assembly and installation, weathering and corrosion.

3.4.2 Fire resistant barriers shall be supplied with all required fasteners, clips, etc., included to make the assembly complete. Instructions for field installation of the fire resistant barriers shall also be included.

3.5 Materials

All materials used in these fire resistant barriers shall be suitable for the intended application. The common material used in fire resistant barriers is galvanized steel. This and any other materials used in fire resistant barriers shall have physical properties necessary to render them suitable for their intended use. When unusual materials are used, special tests may be necessary to verify their suitability.

3.6 Markings

3.6.1 The fire resistant barriers shall be permanently marked and shall include the following minimum information:

- manufacturer's name and address or marking traceable to the manufacturer;
- model or type designation;
- the maximum pipe size used with the component; and,
- FM Approval Mark, (see Appendix B).

3.6.2 Fire resistant barriers that are produced at more than one location shall be identified as the product of a particular location.

3.6.3 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as Approved. The manufacturer shall not place this model or type identification on any other product unless covered by a separate Approval Report.

3.6.4 The FM Approval Mark (see Appendix B) shall be displayed visibly and permanently on the product. The manufacturer shall not use this Mark on any other product unless such product is covered by separate Approval Report.

3.6.5 All markings shall be legible and durable.

3.7 Manufacturer's Installation and Operation Instructions

Installation and maintenance instructions, including any special dimension requirements, shall be furnished by the manufacturer with each shipment of fire resistant barriers. Installation instructions shall include the manufacturer's recommended fasteners.

3.8 Calibration

All examinations and tests performed in evaluation to this standard shall use calibrated measuring instruments traceable and certified to acceptable national or international standards, such as National Institute of Standards and Technology (NIST) of the United States. Copies of calibration certifications will be required at the time of testing.

4. PERFORMANCE REQUIREMENTS

The test set-up for the five fire tests shall include:

- Five fire tests, as defined in Sections 4.2, 4.3, 4.4, 4.5 and 4.6, shall be required. These fire tests shall be conducted in four enclosures as shown in Table 4.1 below:

Table 4.1. Test Enclosures

Fire Test	*Approval Standard Test Section*	*Enclosure*
1, 2	4.2, 4.3	20 ft by 20 ft by "h" ft high (6.1 m by 6.1 m by "h" m high)
3	4.4	20 ft by 16 ft by "h" ft high (6.1 m by 4.9 m by "h" m high)
4	4.5	24 ft by 16 ft by "h" ft high (7.3 m by 4.9 m by "h" m high)
5	4.6	16 ft by 16 ft by "h" ft high (4.9 m by 4.9 m by "h" m high)

- The heights of the test enclosures, ("h"), shall be determined based on the manufacturer's system specifications.
- Temperatures between the internal and external walls of the pipe containing static water shall be monitored at three locations during the fire tests. This pipe is defined as the "Thermocouple Attached Pipe. Three thermocouples, K-type, 30 gauge or equal shall be attached to the pipes through three holes drilled on the pipe surface. The holes shall be drilled to a depth of 0.05 in. (1.3 mm), which is equal to half the depth of the nominal 1 in. SDR 13.5 CPVC pipe used in testing. The three holes shall be located, depending on test scenarios, either (1): at 0.5 ft, 1.0 ft, and 1.5 ft away from one end of a pipe or, (2): at the midpoint of a pipe and 0.5 ft apart from the midpoint, respectively, in both directions. The thermocouples devoted to the pipe temperature measurements shall be denoted as TC1, TC2, and TC3. The thermocouples, K-type, 30 gauge or equal, shall be identified by TC and a number, (i.e., TC1). The location of the thermocouples shall be in the format of TC1 (x,y). The numbers inside the parentheses are the distance in feet from the origin (0,0) in the x-direction and the y-direction, respectively. See individual fire tests for specific locations of the thermocouples.
- At least one joint, consisting of pipe and a coupling, shall be included in each length of sprinkler pipe. This joint shall be prepared in accordance with the CPVC pipe and fittings manufacturer's guidelines using the bonding agent being submitted for Approval. The location of the joint shall be in the format of (x, y). The numbers inside the parentheses are the distance in feet from the origin (0,0) in the x-direction and the y-direction, respectively. See individual fire test for specific locations of test joints.
- Sprinkler actuation shall be detected by a thermocouple installed in close proximity to the sprinkler deflector, this thermocouple shall be designated as TC5.

- In order to measure and control water flow rates discharged from the sprinkler in each test, the static water pressure applied to the sprinkler shall be measured by installing a pressure transducer at the end of the sprinkler pipe.
- Test cribs in accordance with International Maritime Organization (IMO) shall be used as a fuel source. An IMO crib consist of six 18 in. (455 mm) lengths of trade size nominal 2 in. × 2 in. (50 mm × 50 mm) kiln-dried spruce or fir lumber, having a moisture content between 9 percent and 13 percent. The members are placed in four alternate layers at right angles to one another. The members are to be evenly spaced forming a 18 in. × 18 in. (455 mm × 455 mm) square structure, as shown in Appendix D. The heat release rate of each IMO crib is approximately 300 kW.
- The relative humidity of the test enclosure shall not exceed 40 percent.
- Piping and barrier anchorage as well as all other manufacturer's installation guidelines must be strictly followed when conducting the fire tests described in this Approval standard.

4.1 Examination

4.1.1 Requirements

The fire resistant barriers shall conform to the manufacturer's drawings and specifications and to FM Approvals requirements.

4.1.2 Test/Verification

A sample of each type and size of fire resistant barrier shall be examined and compared to the manufacturer's drawings and specifications. It shall be verified that the sample conforms to the physical and structural requirements described in Section 3, General Requirements.

4.2 Fire Test 1

4.2.1 Requirement

A K = 5.6 gal/min/$(psi)^{1/2}$ [8.1 dm^3/min/$(kPa)^{1/2}$] quick response extended coverage light hazard (QRECLH) pendent sprinkler, with a nominal temperature rating of 155°F (68°C) and providing a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density, installed in CPVC pipe with the fire resistant barrier located in the center of a nominal 20 ft by 20 ft (6.1 m by 6.1 m) enclosure of height ''h'' as shown in Figure 4.2.2, shall be able to control a test fire without thermal deformation of the CPVC pipe or fittings. Throughout the test, thermocouple attached pipe temperatures shall not exceed the pipe manufacturer's published thermal deformation temperature. Following suppression of the fire, the water pressure in the sprinkler pipe shall be increased to 175 psi (1205 kPa), for 10 minutes. No damage or distortion to the fire resistant barrier or CPVC pipe and fittings that would impair the operation of the sprinkler or sprinkler system is permitted. The fire resistant barrier shall be removed for visual inspection of the CPVC pipe and fittings. There shall be no thermal deformation of the CPVC pipe or fittings as a result of this test. The sprinkler shall then be plugged and the sprinkler piping system shall be hydrostatically tested to 175 psi (1205 kPa), for 2 minutes. Through visual inspection, no water leakage from the sprinkler piping system is permitted.

4.2.2 Test/Verification

A K = 5.6 gal/min/(psi)$^{1/2}$ [8.1 dm^3/min/(kPa)$^{1/2}$] QRECLH pendent sprinkler with a nominal temperature rating of 155°F (68°C) rating shall be installed at the center of a nominal 20 ft by 20 ft (6.1 m by 6.1 m) enclosure of height "h" as shown in Figure 4.2.2. The (x, y) location of the test joint shall be (1, 10) as shown in Figure 4.2.2. The CPVC piping arrangement shall consist of SDR 13.5 CPVC pipe and schedule 40 or 80 fittings and shall be nominal 1 inch size. Prior to testing, the integrity of the piping systems shall be verified by subjecting the piping system to a hydrostatic pressure of 175 psi (1205 kPa) for a period of 5 minutes. No leakage is permitted.

Temperatures between the internal and external walls of the thermocouple attached pipe shall be monitored by three thermocouples designated TC1, TC2 and TC3 , in Figure 4.2.2. The xcy coordinates of the three thermocouple measuring points shall be as follows: TC1 (0.5, 9.5); TC2 (0.5, 10.0); TC3 (0.5, 10.5), as shown in Figure 4.2.2. Nominal 1 in. SDR 13.5 CPVC sprinkler pipe enclosed by the fire resistant barrier shall be attached to the ceiling while the thermocouple attached pipe, enclosed by the fire resistant barrier, shall be attached to the wall, 10 in. (254 mm) below the ceiling along the y-direction as shown in Figure 4.2.2. Temperature measurement locations shall be 10.5 in. (267 mm) below the ceiling and shall be prepared as shown in Appendix F. The midpoint thermocouple, TC2, shall be located directly above the center of the test fire. Installation of piping and barriers shall be in accordance with manufacturer's guidelines. The piping shall be filled with water prior to ignition of the test crib.

Two IMO cribs shall be placed 2 in. (50 mm) above a 6 in. (152 mm) diameter heptane filled ignition source. See Figure 4.2.2 for the exact location of the cribs.

The time required for sprinkler actuation after ignition of the ignition source, detected by thermocouple TC5, shall be recorded, as well as the temperature values at each thermocouple. Thermocouple TC5, shall be installed in close proximity to the sprinkler deflector. The average water supply pressure to the sprinkler pipe during sprinkler operation shall provide a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density. Once the fire is suppressed, the water pressure shall be increased to 175 psi (1205 kPa) for 10 minutes.

All measured pipe temperatures shall be continuously recorded throughout the duration of the test. All pipe temperatures shall be below the pipe manufacturer's published thermal deformation temperature through the duration of the test. The water pressure variation during the test shall be recorded.

The fire resistant barrier shall be removed and the sprinkler pipe and fittings shall be visually inspected for damage or leakage. The sprinkler shall then be removed and replaced with a plug and the sprinkler pipe and fittings shall be hydrostatically tested to 175 psi (1205 kPa) for two minutes. No water leakage from the sprinkler piping system is permitted.

4.3 Fire Test 2

4.3.1 Requirement

A K = 8.0 gal/min/(psi)$^{1/2}$ [11.5 dm^3/min/(kPa)$^{1/2}$] QRECLH pendent sprinkler with a nominal temperature rating of 155°F (68°C) and providing a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density, installed in CPVC pipe with the fire resistant barrier located in the center of the test enclosure, with height "h", as shown in Figure 4.2.2, shall be able to control a test fire without thermal deformation of the CPVC pipe or fittings. Throughout the test, thermocouple attached pipe temperatures shall not exceed the pipe manufacturer's published thermal deformation temperature. Following suppression of the fire, the water pressure in the sprinkler pipe shall be increased to 175 psi (1205 kPa), for 10 minutes. No damage or distortion to the fire resistant barrier or CPVC pipe and fittings that would impair the operation of the sprinkler or sprinkler system is permitted. The fire resistant barrier shall be removed for visual inspection of the CPVC pipe and fittings. There shall be no thermal deformation of the CPVC pipe or fittings as a result of this test. The sprinkler shall then be plugged and the sprinkler piping system shall be hydrostatically tested to 175 psi (1205 kPa), for 2 minutes. Through visual inspection, no water leakage from the sprinkler piping system is permitted.

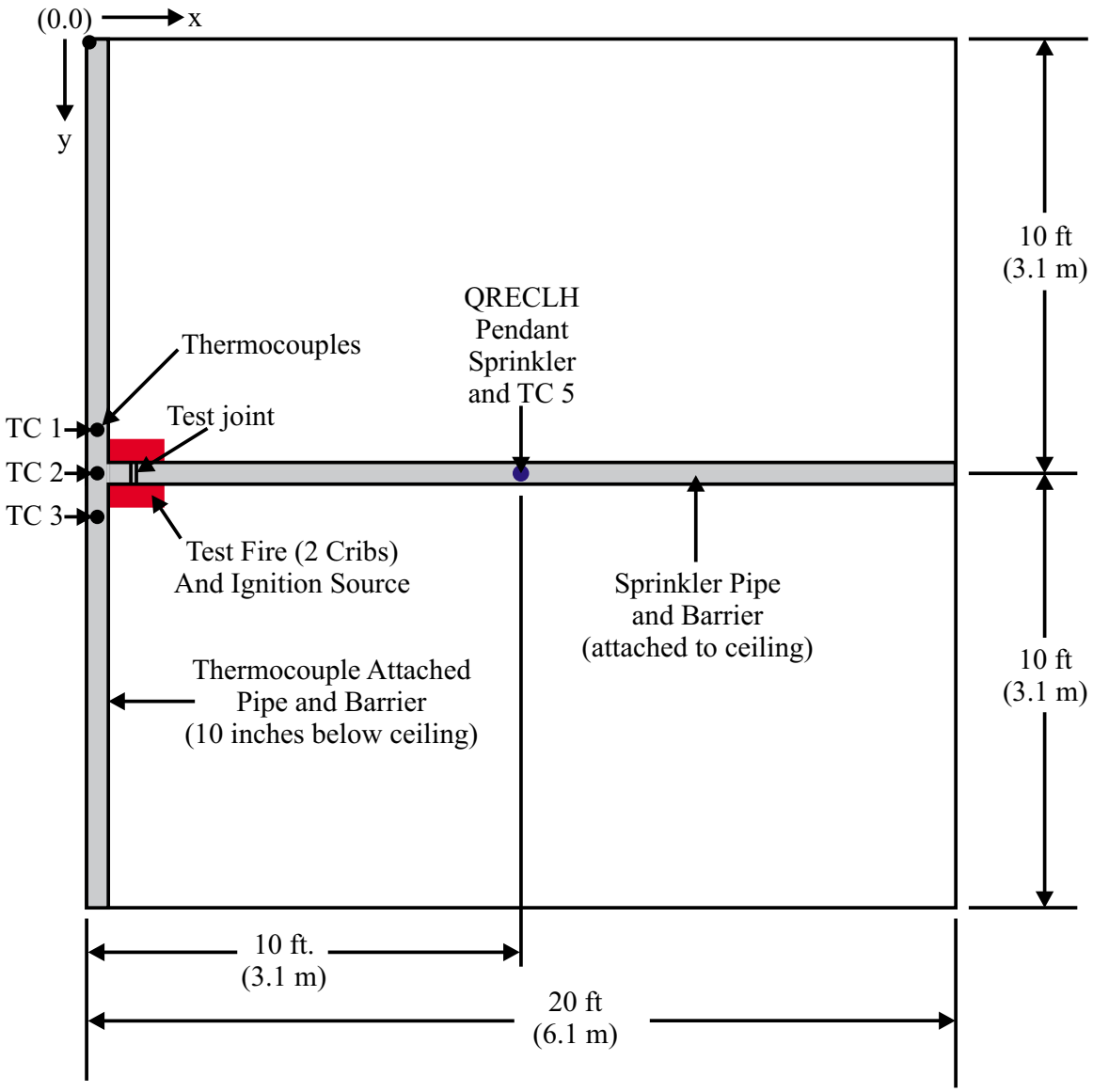


Figure 4.2.2 – Set-Up for Fire Test 4.2 and 4.3

4.3.2 Test/Verification

This test shall be conducted under the same conditions as those in Section 4.2, (Fire Test 1) with the exception of the sprinkler. A K = 8.0 gal/min/(psi)$^{1/2}$ [11.5 dm^3/min/(kPa)$^{1/2}$] QRECLH pendent sprinkler with a nominal temperature rating of 155°F (68°C) rating shall be installed at the center of a nominal 20 ft by 20 ft (6.1 m by 6.1 m) test enclosure of height "h" as shown in Figure 4.2.2. The x-y location of the test joint shall be (1,10) as shown in Figure 4.2.2. The CPVC piping arrangement shall consist of SDR 13.5 CPVC pipe and schedule 40 or 80 fittings and shall be nominal 1 inch size. Prior to testing, the integrity of the piping systems shall be verified by subjecting the piping system to a hydrostatic pressure of 175 psi (1205 kPa) for a period of 5 minutes. No leakage is permitted.

Temperatures between the internal and external walls of the thermocouple attached pipe shall be monitored by three thermocouples designated TC1, TC2 and TC3. The x-y coordinates of the three thermocouple measuring points shall be as follows: TC1 (0.5, 9.5); TC2 (0.5, 10.0); TC3 (0.5, 10.5), as shown in Figure 4.2.2. Nominal 1 in. SDR 13.5 CPVC sprinkler pipe enclosed by the fire resistant barrier shall be attached to the ceiling while the thermocouple attached pipe, enclosed by the fire resistant barrier, shall be attached to the wall, 10 in. (254 mm) below the ceiling along the y-direction as shown in Figure 4.2.2. Temperature measurement locations shall be 10.5 in. (267 mm) below the ceiling and shall be prepared as shown in Appendix F. The midpoint thermocouple, TC2, shall be located directly above the center of the test fire. Installation of piping and barriers shall be in accordance with manufacturer's guidelines. The piping shall then be filled with water prior to ignition of the test cribs.

Two IMO cribs shall be placed 2 in. (50 mm) above a 6 in. (152 mm) diameter heptane filled ignition source. See Figure 4.2.2 for the exact location of the cribs.

The time required for sprinkler actuation after ignition of the ignition source, detected by thermocouple TC5, shall be recorded, as well as the temperature values at each thermocouple. Thermocouple TC5, shall be installed in close proximity to the sprinkler deflector. The average water supply pressure to the sprinkler pipe during sprinkler operation shall provide a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density. Once the fire is suppressed the water pressure shall be increased to 175 psi (1205 kPa) for 10 minutes.

All measured pipe temperatures shall be continuously recorded throughout the duration of the test. All pipe temperatures shall be below the pipe manufacturer's published thermal deformation temperature throughout the duration of the test. The water pressure variation during the test shall be recorded.

The fire resistant barrier shall be removed and the sprinkler pipe and fittings shall be visually inspected for damage or leakage. The sprinkler shall then be removed and replaced with a plug and the sprinkler pipe and fittings shall be hydrostatically tested to 175 psi (1205 kPa) for two minutes. No water leakage from the sprinkler piping system is permitted.

4.4 Fire Test 3

4.4.1 Requirements

A K = 5.6 gal/min/$(psi)^{1/2}$ [8.1 dm^3/min/$(kPa)^{1/2}$] QRECLH sidewall sprinkler, with a nominal temperature rating of 155°F (68°C) and providing a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density, installed in CPVC pipe with the fire resistant barrier located in the center of a 16 ft (4.9 m) long wall within a nominal 20 ft by 16 ft (6.1 m by 4.9 m) enclosure of height "h", as shown in Figure 4.4.2, shall be able to control a test fire without thermal deformation of the CPVC pipe or fittings. Throughout the test, thermocouple attached pipe temperatures shall not exceed the pipe manufacturer's published thermal deformation temperature. Following suppression of the fire, the water pressure in the sprinkler pipe shall be increased to 175 psi (1205 kPa), for 10 minutes. No damage or distortion to the fire resistant barrier or CPVC pipe and fittings that would impair the operation of the sprinkler or sprinkler system is permitted. The fire resistant barrier shall be removed for visual inspection of the CPVC pipe and fittings. There shall be no thermal deformation of the CPVC pipe or fittings as a result of this test. The sprinkler shall then be plugged and the sprinkler piping system shall be hydrostatically tested to 175 psi (1205 kPa), for 2 minutes. Through visual inspection, no water leakage from the sprinkler piping system is permitted.

4.4.2 Tests/Verification

A K = 5.6 gal/min/$(psi)^{1/2}$ [8.1 dm^3/min/$(kPa)^{1/2}$] QRECLH sidewall sprinkler with a nominal temperature rating of 155°F (68°C) rating shall be installed at the center of a 16 ft (4.9 m) long wall of a nominal 20 ft by 16 ft (6.1 m by 4.9 m) test enclosure of height "h", as shown in Figure 4.4.2. The x-y location of the test joint shall be (19.5, 1) as shown in Figure 4.4.2. The CPVC piping arrangement shall consist of SDR 13.5 CPVC pipe and schedule 40 or 80 fittings and shall be nominal 1 inch size. Prior to testing, the integrity of the piping systems shall be verified by subjecting the piping system to a hydrostatic pressure of 175 psi (1205 kPa) for a period of 5 minutes. No leakage is permitted.

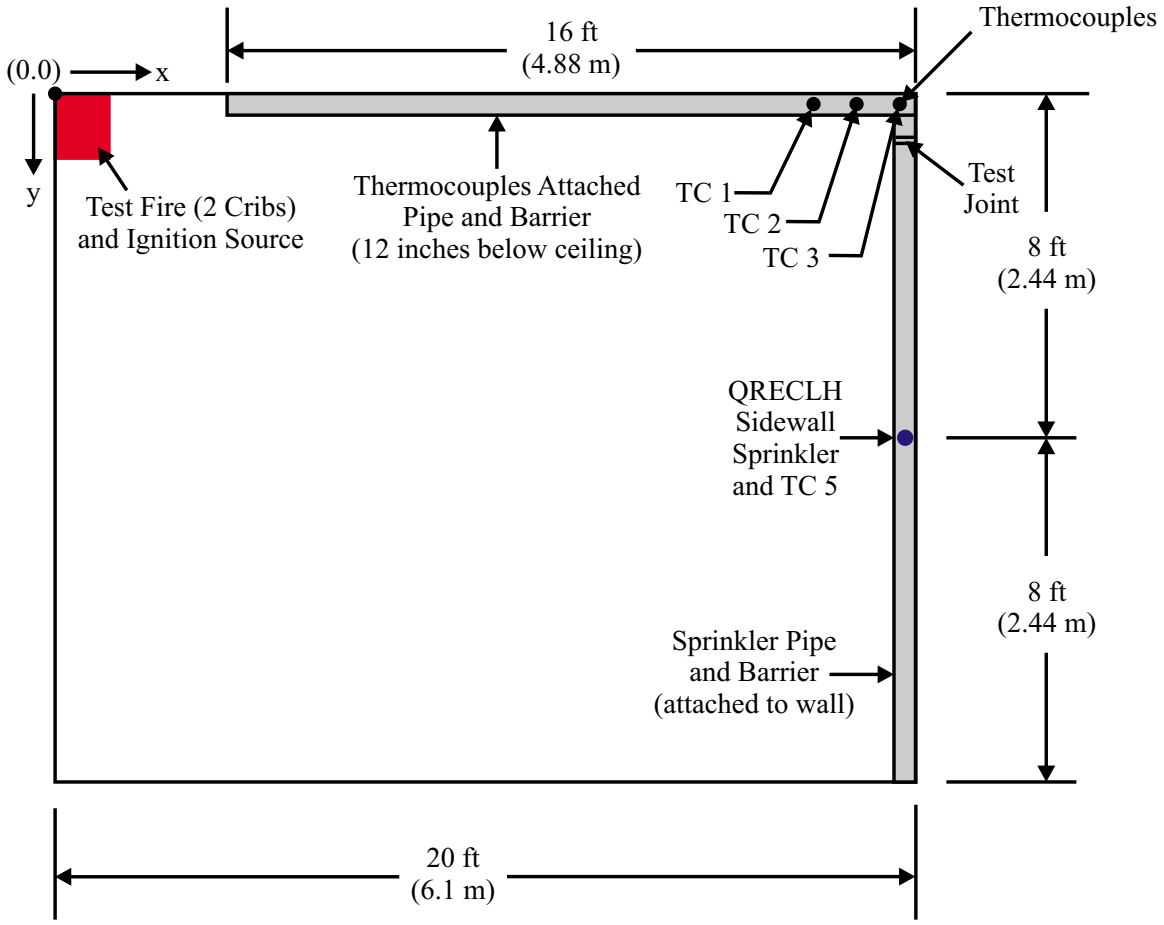


Figure 4.4.2 – Set-Up for Fire Test 4.4

Temperatures between the internal and external walls of the thermocouple attached pipe shall be monitored by three thermocouples designated TC1, TC2 and TC3. The x-y coordinates of the three thermocouple measurement points shall be as follows: TC1 (17.5, 0.5); TC2 (18.5, 0.5); TC3 (19.5, 0.5), as shown in Figure 4.4.2. Nominal 1 in. SDR13.5 CPVC sprinkler pipe enclosed by the fire resistant barrier shall be attached to the wall while the thermocouple attached pipe enclosed by the fire resistant barrier shall be attached to the wall 12 in. (305 mm) below the ceiling along the x direction as shown in Figure 4.4.2. Temperature measurement locations shall be 12.5 in. (317 mm) below the ceiling and shall be prepared as shown in Appendix F. Installation of piping and barriers shall be in accordance with the manufacturers guidelines. The piping shall be filled with water prior to ignition of the test crib.

Two IMO cribs shall be placed 2 in. (50 mm) above a 6 in. (152 mm) diameter heptane filled ignition source. See Figure 4.4.2 for the exact location of the cribs.

The time required for sprinkler actuation after ignition of the ignition source, detected by thermocouple TC5, shall be recorded, as well as the temperature values at each thermocouple. Thermocouple TC5, shall be installed in close proximity to the sprinkler deflector. The average water supply pressure to the sprinkler pipe during sprinkler operation shall provide a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density. Once the fire is suppressed water pressure shall be increased to 175 psi (1205 kPa) for 10 minutes.

All measured pipe temperatures shall be continuously recorded throughout the duration of the test. All pipe temperatures shall be below the pipe manufacturer's published thermal deformation temperature throughout duration of the test. The water pressure variation during the test shall be recorded.

The fire resistant barrier shall be removed and the sprinkler pipe and fittings shall be visually inspected for damage or leakage. The sprinkler shall then be removed and replaced with a plug and the sprinkler pipe and fittings shall be hydrostatically tested to 175 psi (1205 kPa) for 2 minutes. No water leakage from the sprinkler piping system is permitted.

4.5 Fire Test 4

4.5.1 Requirements

A K = 8.0 gal/min/(psi)$^{1/2}$ [11.5 dm^3/min/(kPa)$^{1/2}$] QRECLH sidewall sprinkler, with a nominal temperature rating of 155°F (68°C) and providing a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density, installed in CPVC pipe with the fire resistant barrier located at the center of a 16 ft (4.9 m) long wall in the center of a nominal 24 ft by 16 ft (7.3 m by 4.9 m) enclosure of height "h", shall be able to extinguish a controlled fire without thermal deformation of the CPVC pipe or fittings. Throughout the test, thermocouple attached pipe temperatures shall not exceed the pipe manufacturer's published thermal deformation temperature. Following suppression of the fire, the water pressure in the sprinkler pipe shall be increased to 175 psi (1205 kPa), for 10 minutes. No damage or distortion to the fire resistant barrier or CPVC pipe and fittings that would impair the operation of the sprinkler or sprinkler system is permitted. The fire resistant barrier shall be removed for visual inspection of the CPVC pipe and fittings. There shall be no thermal deformation of the CPVC pipe or fittings as a result of this test. The sprinkler shall then be plugged and the sprinkler piping system shall be hydrostatically tested to 175 psi (1205 kPa), for 2 minutes. Through visual inspection, no water leakage from the sprinkler piping system is permitted.

4.5.2 Test/Verification

A K = 8.0 gal/min/(psi)$^{1/2}$ [11.5 dm^3/min/(kPa)$^{1/2}$] QRECLH sidewall sprinkler with a nominal temperature rating of 155°F (68°C) rating shall be installed at the center of a 16 ft (4.9 m) long wall within a nominal 24 ft by 16 ft (7.3 m by 4.9 m) test enclosure of height "h", as shown in Figure 4.5.2. The x-y location of the test joint shall be (23.5, 1) as shown in Figure 4.5.2. The CPVC piping arrangement shall consist of SDR 13.5 CPVC pipe and schedule 40 or 80 fittings and shall be nominal 1 inch size. Prior to testing, the integrity of the piping systems shall be verified by subjecting the piping system to a hydrostatic pressure of 175 psi (1205 kPa) for a period of 5 minutes. No leakage is permitted.

Temperatures between the internal and external walls of the thermocouple attached pipe shall be monitored by three thermocouples designated TC1, TC2 and TC3. The x-y coordinates of the three thermocouples measurement points shall be as follows: TC1 (21.5, 0.5); TC2 (22.5, 0.5); TC3 (23.5, 0.5), as shown in Figure 4.5.2. Nominal 1 inch CPVC sprinkler pipe enclosed by the fire resistant barrier shall be attached to the wall while the thermocouple attached pipe enclosed by the fire resistant barrier shall be attached to a wall 12 in. (305 mm) below the ceiling along the x direction as shown in Figure 4.5.2. Temperature measurement locations shall be 12.5 in. (320 mm) below the ceiling and shall be prepared as shown in Appendix F. Installation of piping and barriers shall be in accordance with the manufacturer's guidelines. The piping shall be filled with water prior to ignition of the test cribs.

Two IMO cribs shall be placed 2 in. (50 mm) above the 6-in. (152 mm) diameter heptane filled ignition source. See Figure 4.5.2 for the exact location of the cribs.

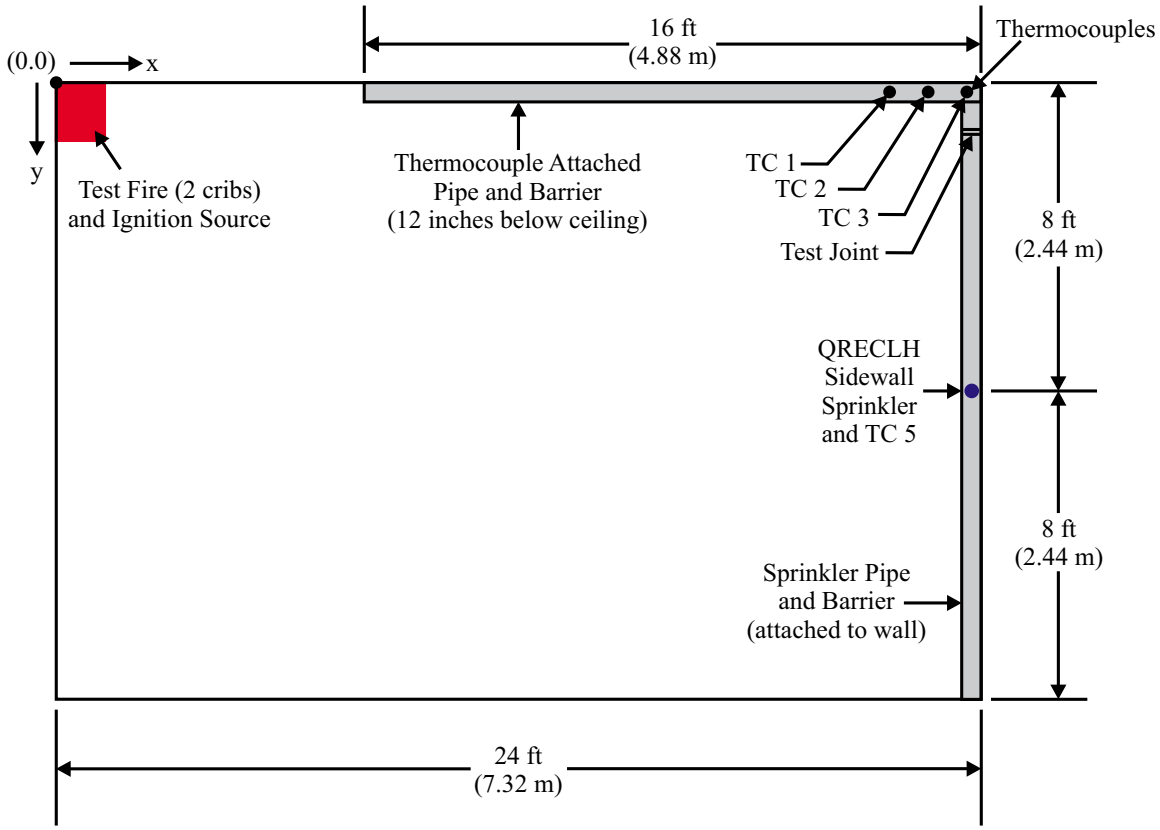


Figure 4.5.2 – Set-Up for Fire Test 4.5

The time required for sprinkler actuation after ignition of the ignition source, detected by thermocouple TC5, shall be recorded, as well as the temperature values at each thermocouple. Thermocouple TC5, shall be installed in close proximity to the sprinkler deflector. The average water supply pressure to the sprinkler pipe during sprinkler operation shall provide a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density. Once the fire is suppressed the water pressure shall be increased to 175 psi (1205 kPa) and maintained for 10 minutes.

All measured pipe temperatures shall be continuously recorded throughout the duration of the test. All pipe temperatures shall be below the pipe manufacturer's published thermal deformation temperature, throughout the duration of the tests. The water pressure variation during the test shall be recorded.

The fire resistant barrier covering the sprinkler pipe shall be removed and the sprinkler pipe and fittings shall be visually inspected for damage or leakage. The sprinkler shall be removed and replaced with a plug and the sprinkler pipe and fittings shall be hydrostatically tested to 175 psi (1205 kPa) for 2 minutes. No water leakage from the piping system is permitted.

4.6 Fire Test 5

4.6.1 Requirements

A K = 3.8 gal/min/(psi)$^{1/2}$ [5.5 dm^3/min/(kPa)$^{1/2}$] quick response, pendent residential sprinkler with a nominal temperature rating of 165°F (74°C) and providing a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density, installed in CPVC pipe with the fire resistant barrier located in the center of a nominal 16 ft by 16 ft (4.9 m by 4.9 m) enclosure of height "h", as shown in Figure 4.6.2, shall be able to extinguish a controlled fire without thermal deformation of the CPVC pipe or fittings. Throughout the test, thermocouple attached pipe temperatures shall not exceed the pipe manufacturer's published thermal deformation temperature. Following suppression of the fire, the water pressure in the sprinkler pipe shall be increased to 175 psi (1205 kPa), for 10 minutes. No damage or distortion to the fire resistant barrier or CPVC pipe and fittings that would impair the operation of the sprinkler or sprinkler system is permitted. The fire resistant barrier shall be removed for visual inspection of the CPVC pipe and fittings. There shall be no thermal deformation of the CPVC pipe or fittings as a result of this test. The sprinkler shall then be plugged and the sprinkler piping system shall be hydrostatically tested to 175 psi (1205 kPa), for 2 minutes. Through visual inspection, no water leakage from the sprinkler piping system is permitted.

4.6.2 Tests/Verification

A K = 3.8 gal/min/(psi)$^{1/2}$ [5.5 dm^3/min/(kPa)$^{1/2}$] quick response pendent residential sprinkler with a nominal temperature rating of 165°F (74°C) rating shall be installed at the center of a nominal 16 ft by 16 ft (4.9 m by 4.9 m) enclosure of height "h", as shown in Figure 4.6.2. The x-y location of the test joint shall be (1, 8) as shown in Figure 4.6.2. The CPVC piping arrangement shall consist of SDR 13.5 CPVC pipe and schedule 40 or 80 fittings and shall be nominal 1 inch size. Prior to testing, the integrity of the piping systems shall be verified by subjecting the piping system to a hydrostatic pressure of 175 psi (1205 kPa) for a period of 5 minutes. No leakage is permitted.

Temperatures between the internal and external walls of the thermocouple attached pipe during the fire tests shall be monitored by three thermocouples designated TC1, TC2, and TC3. The x-y coordinates of the three thermocouple measurement points shall be as follows: TC1 (0.5, 7.5); TC2(0.5, 8.0); TC3 (0.5, 8.5), as shown in Figure 4.6.2. Nominal 1 in. SDR13.5 CPVC sprinkler pipe enclosed by the fire resistant barrier shall be attached to the ceiling while the thermocouple attached pipe, covered with the fire resistant barrier, shall be attached to the wall 10 in. (255 mm) below the ceiling along the y-direction, as shown in Figure 4.6.2. Temperature measurement locations shall be 10.5 in. (265 mm) below the ceiling and shall be prepared as shown in Appendix F. The midpoint thermocouple, TC2, shall be located directly above the center of the test fire. Installation of piping and barriers shall be in accordance with the manufacturer's guidelines. The piping shall be filled with water prior to ignition of the test crib.

A single IMO crib shall be placed 2 in. (50 mm) above a 6 in. (152 mm) diameter heptane filled ignition source. See Figure 4.6.2 for the exact location of the crib.

The time required for sprinkler actuation after ignition of the ignition source, detected by thermocouple TC5, shall be recorded, as well as the temperature values at each thermocouple. Thermocouple TC5, shall be installed in close proximity to the sprinkler deflector. The average water supply pressure to the sprinkler pipe during sprinkler operation shall provide a 0.1 gal/min/ft^2 (4.1 mm/min) discharge density. Once the fire is suppressed the water pressure shall be increased to 175 psi (1205 kPa) for 10 minutes.

All measured pipe temperatures shall be continuously recorded throughout the duration of the test. All pipe temperatures shall be below the pipe manufacturer's published thermal deformation temperature, throughout the duration of the test. The water pressure variation during the test shall be recorded.

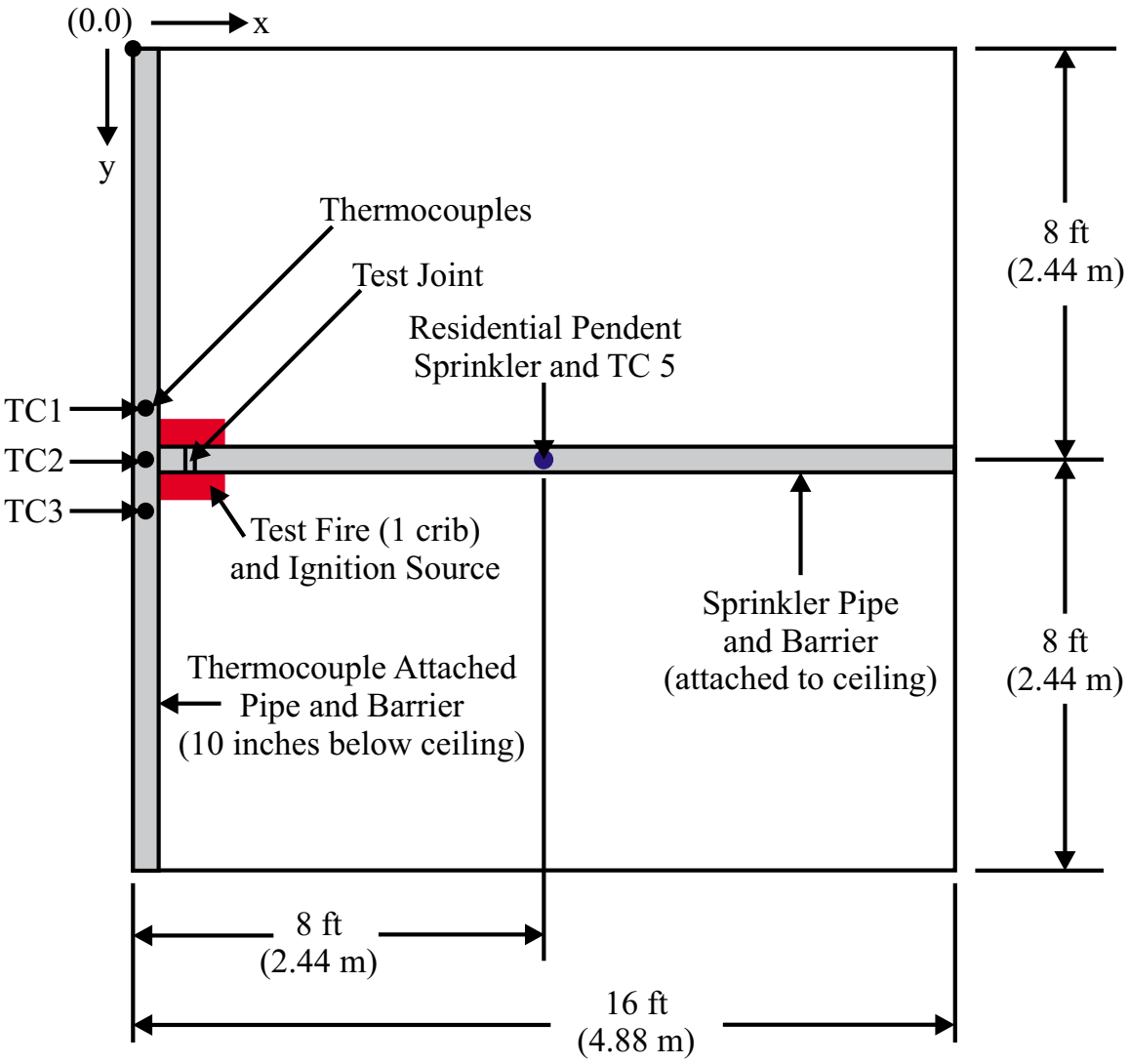


Figure 4.6.2 — Set-Up for Fire Test 4.6

The fire resistant barrier shall be removed and the sprinkler pipe and fittings shall be visually inspected for damage or leakage. The sprinkler shall then be removed and replaced with a plug and the sprinkler pipe and fittings shall be hydrostatically tested to 175 psi (1205 kPa) for 2 minutes. No water leakage from the sprinkler piping system is permitted.

4.7 Additional Tests

Additional tests may be required, depending on design features, results of any tests, material application, or to verify the integrity and reliability of the fire resistant barriers, at the discretion of FM Approvals.

Unexplainable failures shall not be permitted. A re-test shall only be acceptable at the discretion of FM Approvals and with adequate technical justification of the conditions and reasons for failure.

5. OPERATIONS REQUIREMENTS

A quality control program is required to assure that subsequent fire resistant barriers produced by the manufacturer at an authorized location shall present the same quality and reliability as the specific fire resistant barriers examined. Design quality, conformance to design, and performance are the areas of primary concern. Design quality is determined during the Approval examination and tests, and is covered in the Approval Report. Conformance to design is verified by control of quality and is covered in the Facilities and Procedures Audit (F&PA). Quality of performance is determined by field performances and by periodic re-examination and testing.

5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and,
- handling and disposition of non-conformance materials.

In order to assure adequate traceability of materials and products, the manufacturer shall maintain records of all quality control tests performed for a minimum period of two years from the date of manufacture.

5.1.2 Documentation/Manual

There should be an authoritative collection of procedures and policies. Such documentation shall provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.3 Drawing and Change Control

The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents identified in the Approval Report must be reported to, and authorized by, FM Approvals prior to implementation for production. The manufacturer shall assign an appropriate person or group to be responsible for reporting proposed changes to Approved or Listed products to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals Form 797, *Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report*. Records of all revisions to all Approved products shall be maintained.

5.2 Facilities and Procedures Audit (F&PA)

5.2.1 An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality control program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a consistently uniform and reliable product. Initial inspections of facilities already producing similar products may be waived at the discretion of FM Approvals.

5.2.2 Unannounced follow-up inspections shall be conducted at least annually by FM Approvals, or its designate, to determine continued compliance. More frequent audits may be required by FM Approvals.

5.2.3 The client shall manufacture the product or service only at the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the FM Approval mark is not permitted at any other location without prior written authorization by FM Approvals.

5.3 Manufacturer's Responsibilities

The manufacturer shall notify FM Approvals of changes in product construction, design, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation of such changes.

5.4 Manufacturing and Production Tests

The manufacturer shall measure and record critical component dimensions, material thickness, and markings (as applicable) at the beginning of each production run. Thereafter, these measurements shall be recorded every 4 hours. The number of samples to be measured shall be based on manufacturer's Quality Control Manual, but in no case shall be less than five samples. Measurements shall be compared to the latest revision of the component drawings.

APPENDIX A

UNITS OF MEASUREMENT

FLOW:
gal/min – ''gallon per minute'' (L/min – ''liters per minute'')
L/min = gal/min × 3.7854

FORCE:
lb_f – ''pounds force''; (N – ''Newtons'')
lb_f = N × 4.4482

K-FACTOR:
gal/min/$(psi)^{1/2}$ – ''gallons per minute per square root of pounds per square inch''
(L/min/$(kPa)^{1/2}$ – ''liters per minute per square root of kilopascals''
(L/min/$(kPa)^{1/2}$ = gal/min/$(psi)^{1/2}$ × 1.442

LENGTH:
in. – ''inches''; (mm – ''millimeters'')
mm = in. × 25.4
ft – ''feet''; (m – ''meters'')
m = ft × 0.3048

MASS:
lb – ''pounds''; (kg – ''kilograms'')
lb = kg × 0.4536

PRESSURE:
psi – ''pounds per square inch'' (kPa – ''kilopascals'')
kPa = psi × 6.8948
psf – ''pounds per square foot'' (kPa – ''kilopascals'')
kPa = psf × 0.0479
bar = psi × 0.06895

TEMPERATURE:
°F – ''degrees Fahrenheit'' (°C – ''degrees Celsius'')
°C = (°F – 32) × 0.556

VOLUME PER UNIT AREA:
gal/min/ft^2 – ''gallons per minute per square feet''
(mm/min – ''millimeters per minute'')
mm/min = 40.75 × gal/min/ft^2

APPENDIX B

APPROVAL MARKS

REPRODUCTION ART: FM Approval Marks

For use on nameplates, in literature, advertisements, packaging and other graphics.

1) The FM Approvals diamond mark is acceptable to FM Approvals as an Approval mark when used with the word "Approved."

2) The FM Approval logomark has no minimum size requirement, but should always be large enough to be readily identifiable.

3) Color should be black on a light background or a reverse may be used on a dark background.

For Cast-On Marks

4) Where reproduction of the mark described above is impossible because of production restrictions, a modified version of the diamond is suggested. Minimum size specifications are the same as for printed marks. Use of the word "Approved" with this mark is optional.

NOTE: These Approval marks are to be used only in conjunction with products or services that have been FM Approved. The FM Approval marks should never be used in any manner (including advertising, sales or promotional purposes) that could suggest or imply FM Approval or endorsement of a specific manufacturer or distributor. Nor should it be implied that Approval extends to a product or service not covered by written agreement with FM Approvals. The Approval marks signify that products or services have met certain requirements as reported by FM Approvals.

Additional reproduction art is available through

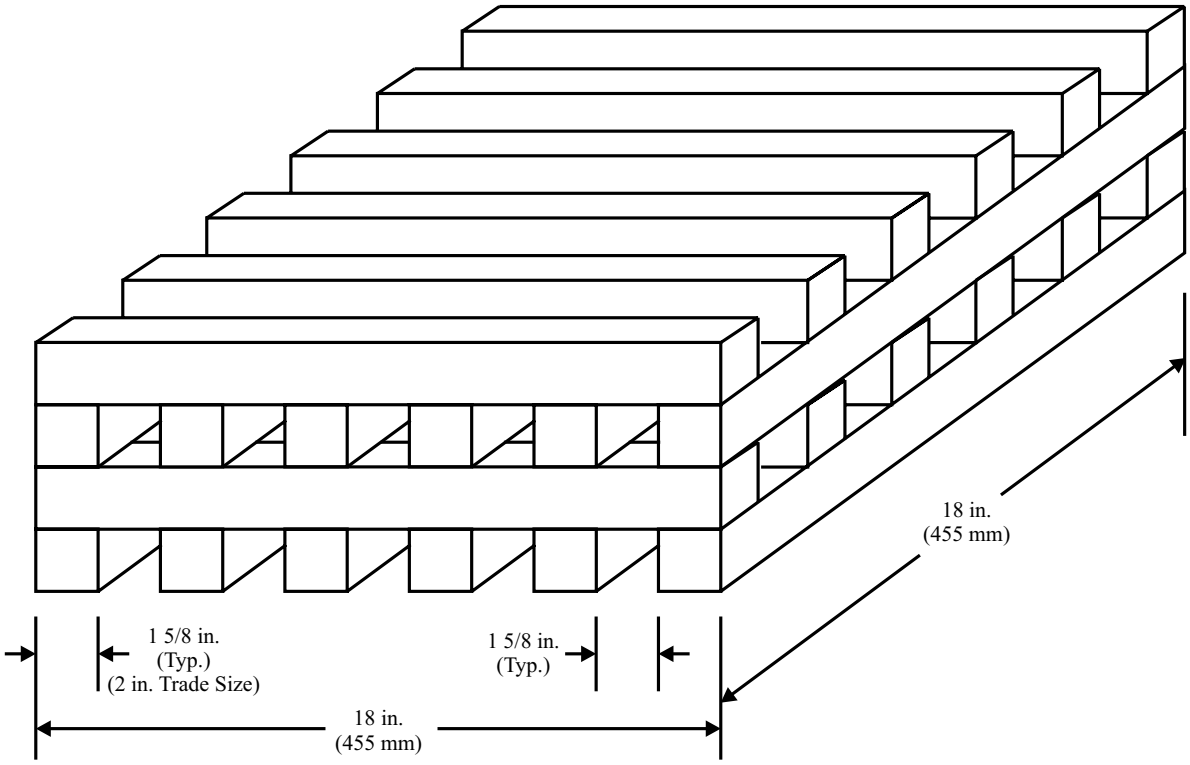
FM Approvals
P.O. Box 9102,
Norwood, Massachusetts 02062
U.S.A.

APPENDIX C
SAMPLE LISTING

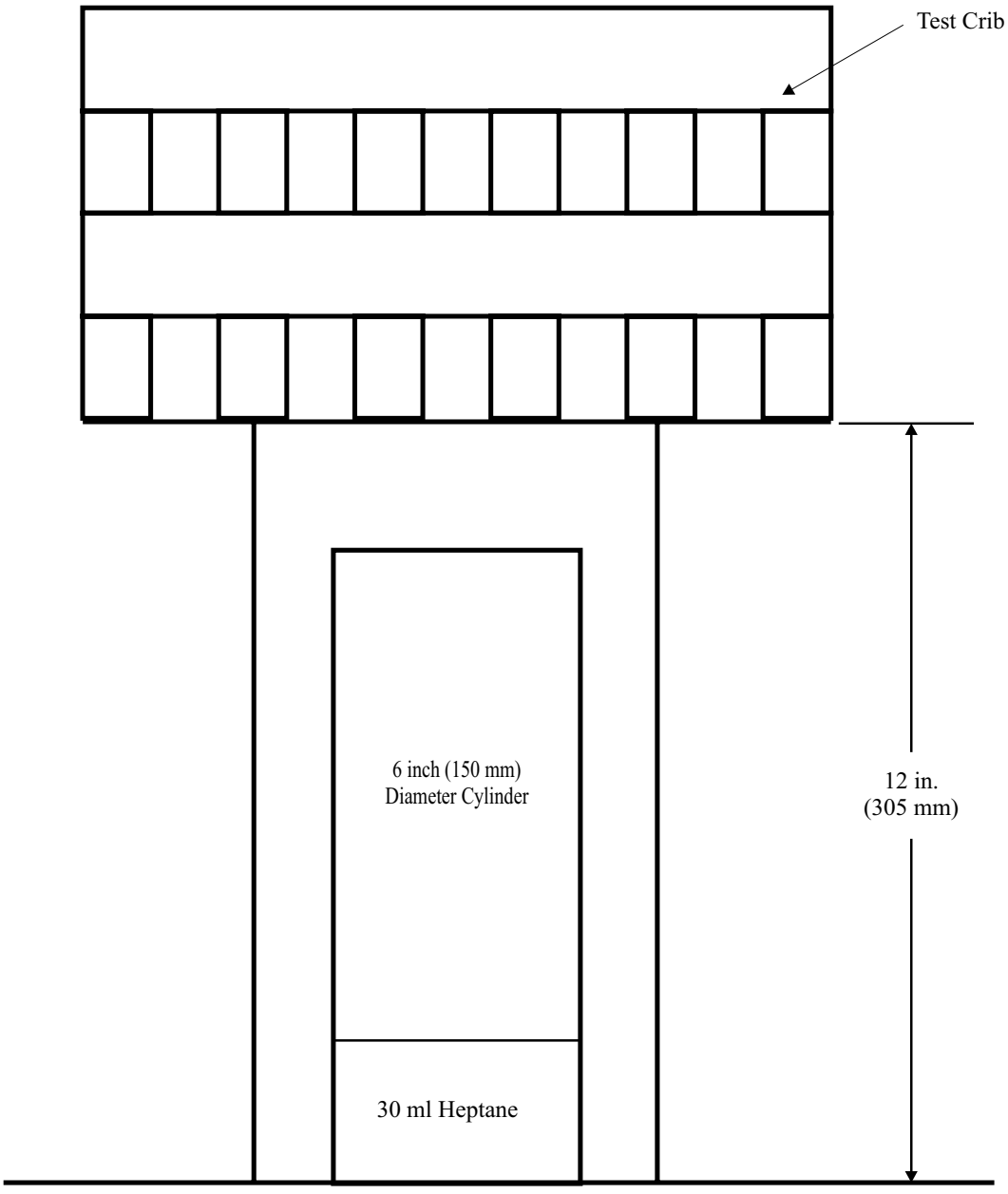
Company Name, Company Address

Product Designation	*Approved for Use With*
Model XY Fire Resistant Barrier Approved to "h" Ceiling Height	Company XX CPVC Pipe and Fittings using the Following Joint Cements: AA AB BA

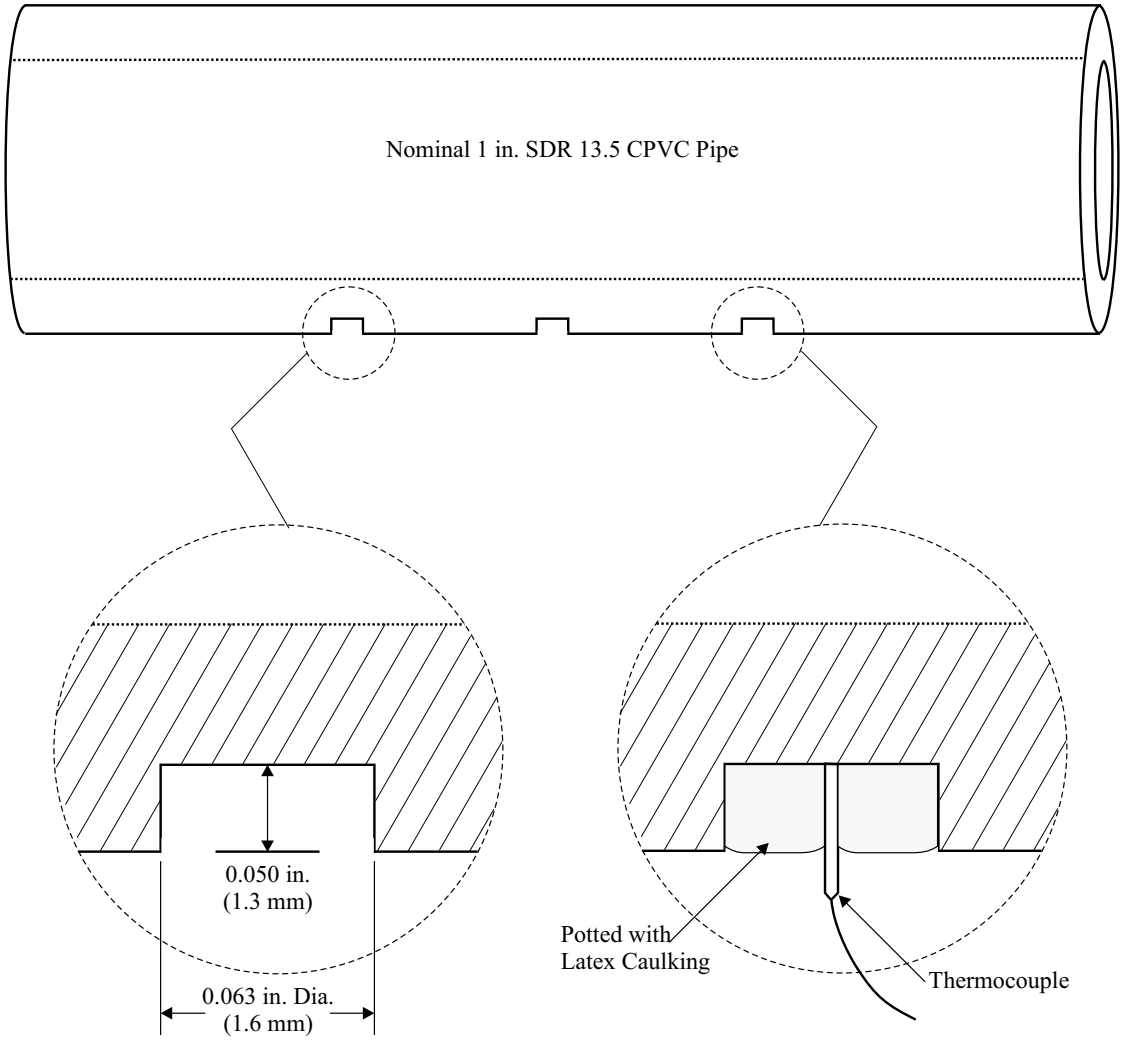
APPENDIX D
IMO CRIB



APPENDIX E
IGNITION SOURCE



APPENDIX F
THERMOCOUPLE ATTACHED PIPE



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