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Examination Standard for Plastic Pipe and Fittings for Automatic Sprinkler Systems

Class Number 1635

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Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

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1. INTRODUCTION

1.1 Purpose

1.1.1 This standard states certification requirements for plastic pipe and fittings in light hazard occupancies for use in automatic wet sprinkler fire protection systems.

1.1.2 Testing and certification criteria may include performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2 Scope

1.2.1 This standard encompasses the design and performance requirements for plastic pipe and fittings in light hazard occupancies for use in automatic wet sprinkler fire protection systems. The intent is to determine:

- That specific pipe and fittings are capable of maintaining sprinkler system integrity and performance during a fire.
- If one of the intended uses of the plastic pipe and fittings is in a hybrid sprinkler system using internally coated steel pipe (*i.e.,* plastic pipe connected to internally coated steel pipe), evaluation of the plastic pipe and fittings under this standard shall include chemical compatibility testing with all certified manufacturer applied internally coated steel pipe (*i.e.,* internally coated by the manufacturer).

1.2.2 Plastic pipe and fittings examined in accordance with this standard may be certified for unexposed (shielded) or exposed service in light hazard occupancies.

1.2.2.1 Products certified for unexposed use require a permanently installed non-combustible barrier with a minimum 15 minute rating in accordance with ASTM E119. Alternatively, pipe and fittings discussed in this standard may be used with a certified fire resistant barrier evaluated in accordance with Standard 1636, "*Fire Resistant Barriers for use with CPVC Pipe and Fittings in Light Hazard Occupancies*". Only plastic pipe and fittings tested with a specific fire resistant barrier in accordance with Standard 1636 may be used.

1.2.2.2 Products certified for exposed use may be used exposed when installed in accordance with the manufacturer's installation instructions and all of the following criteria are met:

• *Occupancy must be covered by an HC-1 Hazard Category.*

• *Sprinklers must have quick response thermal sensing elements.*

• *Sprinkler systems must be wet pipe type.*

1.2.3 Plastic pipe and fittings certified to this standard have not been evaluated for use in seismically active areas.

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 plastic pipe and fittings for the purpose of obtaining certification.

1.4 Basis for Certification

Certification 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 for certification;
- the durability and reliability of the product.

1.4.2 An examination of the manufacturing facilities and audit of the quality control procedures may be conducted to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance audits may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5 Basis for Continued Certification

The basis for continual certification may include the following based on the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agency's product surveillance program.

1.6 Effective Date

The effective date of this certification standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this standard is eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7 System of Units

Units of measurements 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. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

1.8 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies.

IEEE/ASTM SI 10, *American National Standard for Metric Practice.*

ANSI/ASME B1.20.1, *Pipe Threads, General Purpose (Inch).*

ASTM D543, *Standard Specification for Evaluating the Resistance of Plastics to Chemical Reagents*

ASTM D638, S*tandard Test Method for Tensile Properties of Plastics*

ASTM D1598, *Standard Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure*

ASTM D2444, *Standard Test Method for Determination of the Impact Resistance of Thermoplastic Pipe and Fittings by Means of a Tup (Falling Weight)*

ASTM D2837, *Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products*

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*

ASTM E1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

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

ASTM F2389, *Standard Specification for Pressure-Rated Polypropylene (PP) Piping Systems*

ASTM G154, *Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials*

NFPA 13, *Standard for the Installation of Sprinkler Systems*

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One-and Two-Family Dwellings and Manufactured Homes*

NSF/ANSI Standard 61, *Drinking Water System Components - Health Effects*

International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*

ISO 9080, *Plastics piping and ducting systems – Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation.*

1.9 Terms and 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. Acceptance is based upon an overall evaluation of the installation. Acceptance is not a characteristic of a product. It is installation specific. A product accepted for one installation may not be acceptable elsewhere.

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.

Hazard Category 1 (HC-1)

Areas with light overall combustible loading with limited combustibles used in processes, or operations of low hazard. This includes combustible furnishings that are typically noncontinuous in well-subdivided areas. This hazard category does not include any incidental storage of plastics, or plastics used in the construction of walls and/or ceilings. Examples include residential, offices, noncombustible manufacturing, and hospitals.

Hydrostatic Design Basis (HDB)

One of a series of established stress values for a plastic material. It is obtained by categorizing the Long Term Hydrostatic Strength of the material as described in ASTM D2837 or equivalent national/international standard.

Hydrostatic Design Stress (HDS)

The maximum allowable stress used in the design of plastic pipe of a given material. It is obtained by multiplying the Hydrostatic Design Basis (*HDB*) by a design factor.

$$HDS = HDB \times DF$$

Light Hazard Occupancy

NFPA 13, "Standard for Installation of Sprinkler Systems", defines classes of occupancies. The light hazard occupancies wherein it is anticipated that plastic sprinkler piping will be used include hotels, hospitals, offices, schools, apartment buildings, and similar non-mercantile, non-manufacturing or non-warehousing occupancies. These occupancies are characterized by relatively low combustible loadings and completely finished interiors.

Long Term Hydrostatic Strength (LTHS)

Plastic materials exhibit a time-dependant response to stress. This occurs in a predictable fashion. If samples of plastic pipe are pressurized to various levels, they will fail after periods of time proportional to those pressures. The specific relationship is that the logarithm of the time to failure is negatively proportional to the logarithm of the stress.

$$log\ T = a - b\ log\ S$$

Where *a* and *b* are constants.

This stress, *S*, is the hoop stress in the material due to internal pressure at a constant temperature. ASTM D2837 details test procedures for obtaining this relationship for thermoplastic piping products. The relationship is then used to determine a particular maximum *S* that should not cause failure until at least after a minimum desired life. That *S* is termed the Long Term Hydrostatic Stress (*LTHS*) for the material in question. For purposes of certification of plastic piping, the $T = 50$ years shall be used to determine *LTHS*.

Permanently Installed, Non-Combustible Barriers

A permanently installed barrier is one that cannot be removed without substantial cosmetic damage (e.g., a plastered ceiling). The intent of the requirement is to inhibit casual removal of the barrier for various purposes of convenience, such as re-routing of wiring, as this leads to protracted periods of exposure of the piping. Drop-in ceiling tiles, as used in suspended ceilings are specifically considered not to be "permanently installed" for the purposes of this definition. Non-combustible is defined as having a minimum finish fire rating of 15 minutes when tested per ASTM E119.

Pressure Rating (PR)

The maximum constant internal pressure plus surge pressure allowance, at a given temperature, that can be successfully withstood by pipe of a given Hydrostatic Design Stress and Standard Dimension Ratio (*SDR*).

$$PR = (2 \times HDS) \div (SDR - 1)$$

Design Factor (DF)

A number, less than or equal to 0.5, by which the Hydrostatic Design Basis (*HDB*) is multiplied to obtain the Hydrostatic Design Stress (*HDS*). This *DF* is used to account for variations in conditions from those contemplated in the design of an installation, rough handling of piping, and manufacturing variations.

Standard Dimension Ratio (SDR)

The ratio of average outside diameter of a pipe to its minimum wall thickness. This number is constant for all sizes of pipe of a given material and pressure rating.

Wet System

A system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that the water discharges immediately from sprinklers opened by a fire.

2. GENERAL INFORMATION

2.1 Product Information

2.1.1 Plastic piping for sprinkler systems can be identical in materials, sizes, wall thicknesses, and other design and manufacturing aspects to plastic piping for domestic or process water systems. Some specialized fittings designed to facilitate sprinkler installation are available, and many products have been specifically designed for fire protection service.

2.1.2 Piping is usually either extruded (pipes) or injection molded (fittings) of specific thermoplastic formulations, in conformance to nationally or internationally recognized standards.

2.1.3 Pipe and fittings usually must be of the same material to provide for secure jointing. Chlorinated polyvinyl chloride (CPVC) based products typically are joined by solvent cementing, while polyolefin (PO) based products are usually joined by thermal fusion methods. Composite, reinforced (thermosetting) products are usually joined by epoxy cements or mechanical connections.

2.2 Certification Application Requirements

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

- a complete list of all models, types, sizes, and options for the products or services being submitted for certification consideration;
- general assembly drawings and one complete set of manufacturing drawings;
- materials list(s) and material specifications;
- 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

2.3.1 Following set-up and authorization of a certification examination, the manufacturer shall submit samples for examination and testing. Sample requirements are to be determined by the certification agency following review of the preliminary information. Sample requirements may vary depending on formulation features and results of prior testing. Testing shall use regular production pipe and fittings assembled per the manufacturer's published instructions. All joining techniques submitted shall be tested in all sizes submitted. However, all configurations need not be tested for qualification of a given line. The certification agency will designate those items to be tested which, in its judgment, adequately sample the designs. Any decision to use data generated utilizing prototypes is at the discretion of the certification agency. The manufacturer's test facilities may be used for testing. If testing is performed at the certification agency's facilities, it is the manufacturer's responsibility to provide any necessary test fixtures. Any manufacturer supplied test fixtures shall be returned to the manufacturer at their request.

2.3.2 In order to qualify for automatic sprinkler system service, plastic piping shall be examined on a design-by-design, manufacturer-by-manufacturer, and plant-by-plant basis. This is because the manufacture of plastic piping requires sufficient art in its execution that identical designs, executed in identical materials by different manufacturers or, even by different plants of the same manufacturer, have been seen to perform differently in testing. Sample piping, selected in conformance to this criterion shall satisfy all of the following performance requirements and be installed in a manner identifiable as being within the scope of

conditions defined by the testing.

2.3.3 The certification examination consists of determination of hydrostatic design basis (*HDB*) of the specific material used, verification of an appropriate design factor of safety, tests of mechanical durability and practicality, and other tests, as noted. A complete review of installation specifications shall be conducted to assure, as far as possible, a practical and reliable installation. Inspection of the product manufacturing facility shall be conducted to assure conformance with the requisite tests and specifications.

3. GENERAL REQUIREMENTS

3.1 Certification Limitation

Certification of pipe and fittings made with a specific compound shall be limited to use with the specific bonding agent or method used in the certification testing. As such, certification of multiple compounds and bonding agents, and combinations thereof, shall require a complete test program for each compound or 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 certification investigation.

3.3 Design Requirements

3.3.1 Plastic pipe may be formed of either homogeneous or composite materials. Either type of material shall be assigned a hydrostatic design basis (*HDB*) for water at both 73°F (23°C) and at least 120°F (49°C). The upper temperature limit is to be specified by the manufacturer seeking certification. These HDB values shall be derived from sustained pressure tests conducted in accordance with ASTM D1598 and evaluated in accordance with ASTM D2837 or other international standard (ISO 9080) for thermoplastic materials. The testing shall have been performed on pipe made of the same raw material as that of the pipe submitted for certification and produced on equipment and under conditions equivalent to those to be used in its commercial production. The hydrostatic design stress (*HDS*) shall then be established by multiplying the *HDB* by a factor of no greater than 0.5. The actual factor used shall be lower if necessary to provide at least a projected 50 year life at the rated pressure and temperature. If the Plastic Pipe Institute (PPI) has certified the material in question to have an *HDB* meeting these requirements, even if that certification is based upon a documented equivalency to other pipe rather than on direct testing to the pipe submitted for certification, that *HDB* shall be acceptable.

The manufacturer shall submit the long term hydrostatic test data used to calculate the *HDB*. The certification agency will verify the calculations and the suitability of the data per the applicable ASTM or international standard.

The purpose of assigning an *HDS* at two temperatures is as follows:

- Generally, the *HDS* developed for the higher temperature will be the lesser value. Thus, the *HDS* will determine the pressure rating.
- The *HDS* developed at 73°F (23°C) is for convenience of conducting tests at this temperature for evaluation of the adequacy of the design factor.
- The assumption is that reduction in strength of the piping caused by abuse and measured at the 73°F (23°C) temperature will be proportional to those for the higher temperature. Thus, it will not be necessary to conduct abuse tests at the higher temperature.

3.3.2 Plastic fitting materials shall be only those defined by a recognized material specification.

3.3.3 Plastic piping materials that are not suitable for potable water service, as listed for this service by the NSF International per NSF/ANSI Standard 61, the CSA Testing Laboratory or other nationally recognized and accredited testing laboratories shall be marked as indicated in section 4.1.

3.3.4 All piping shall be designed and manufactured in accordance with the dimensional and other requirements of the recognized national standard for the products in question. Where such a standard does not exist, the manufacturer shall be prepared to submit detailed dimensional drawings for all items and shall attempt to conform to generally accepted industry practice for comparable products.

3.3.5 The minimum nominal pipe size for all pipe and fittings shall be 3/4 in.

3.3.6 The minimum water passage through all pipe and fittings and all joints of every type shall be 5/8 in. (15.9 mm) diameter.

3.3.7 All items shall be pressure rated at no fewer than two temperatures. The minimum pressure rating at both temperatures shall be 175 psi (1205 kPa). The two pressure temperatures shall be 73°F (23°C) and at least 120°F (49°).

3.3.8 The maximum pressure ratings for pipe at both rating temperatures shall be determined using the following relation and the hydrostatic design stress (*HDS*) values for each temperature as defined in paragraph 3.3.1:

$$PR = (2 \times HDS) \div (SDR - 1)$$

Where: *PR* = the pressure rating in psi or kPa,
HDS = the hydrostatic design stress in the same units, and
SDR = the dimension ratio of the pipe

A manufacturer need not take full advantage of the properties of his material in establishing pressure ratings. That is, more conservative ratings than those derived from this calculation may be assigned, as long as the minimum requirements of paragraph 3.3.7 have been met.

3.3.9 Pressure ratings for plastic fittings cannot be easily determined. Fittings submitted for use with a given pipe must be of compatible material characteristics and shall not fail before the pipe when tested to meet the requirements of paragraph 4.2.

3.3.10 Fittings may be designed for any type of connection to pipe, provided that the performance requirements of this standard are met. However, when the joining method is other than tapered pipe threads (NPT), adapter fittings shall be provided to connect pipe and fittings to NPT system components. NPT connections shall be designed in accordance with ANSI/ASME B1.20.1. Alternatively, pipe fittings intended for sale outside the United States may be supplied with pipe threads conforming to the relevant recognized national standard that will provide compatibility with that nation's automatic sprinkler system components.

3.3.11 All tests, unless otherwise noted, shall be performed at an ambient temperature of 73°F (23°C).

3.4 Markings

3.4.1 The certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

3.4.2 Piping shall also be marked in accordance with the recognized national standard to which it is made.

3.4.3 A national standard notwithstanding, pipe shall also carry at least the following minimum markings:

- Manufacturer's name, code or trademark
- Material designation
- Nominal size
- Specific source code, indicating location of manufacture (if more than one)
- Date of manufacture code
- Pressure rating, or class, and rating temperature
- If certified for unexposed service only, the words "UNEXPOSED SERVICE ONLY" in close juxtaposition to the certification agency mark
- If piping material is not certified for potable water service the words "NOT FOR POTABLE SERVICE".

3.4.4 Pipe shall be marked, at minimum, every 3 feet (1 m).

3.4.5 A national standard notwithstanding, each fitting shall also carry at least the following minimum markings:

- Manufacturer's name, code or trademark
- Material designation
- Nominal size
- Specific source code, indicating location of manufacture (if more than one)
- Unique item identification, traceable to catalogued pressure rating, or class, and rating temperature
- Mold cavity identification

3.4.6 All markings shall be legible throughout the useful life of the product.

3.5 Manufacturer's Installation and Operation Instructions

The manufacturer shall provide installation instructions which clearly indicate whether the pipe and fittings qualified under this standard are manufactured for exposed or unexposed, wet system service. For unexposed service, suggested suitable minimum enclosure requirements (non-combustible, firestops, etc.) shall be stated as well as insulation requirements for piping to be routed in enclosures exposed to freezing temperature. Suitable designs for transition connections to other materials shall be specified. Hanger types, spacing, and configurations shall also be specified. Minimum bending radii and other relevant installation cautions shall be specified. The certification agency shall determine the minimum acceptable extent of these instructions based upon the specific nature of the pipe and fittings submitted for certification and upon trials of the joining methods and other relevant techniques specified. Any instructions specific to certification constraints may be labeled as such. Certification agency required instructions may be included in a more general instruction publication, provided that it is clearly stated that certification of these products is contingent upon observance of the certification agency's constraints.

3.6 Calibration

Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of its stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service accreditation certificate as an ISO/IEC 17025 calibration laboratory should be available.

When the inspection equipment and/or environment is not suitable for labels or stickers other methods, such as etching of control numbers on the measuring device, is allowed provided documentation is maintained on the calibration status of the equipment.

4. PERFORMANCE REQUIREMENTS - EXPOSED/UNEXPOSED

4.1 Standard Designs

4.1.1 If the manufacturer's literature or piping markings reference any recognized standard specifying design, manufacture, or performance, the certification agency shall verify, as a part of its examination, that all criteria of such a referenced standard are met. The intent of the requirement is that plastic piping conforms to any recognized standard to which it is manufactured.

4.1.2 The manufacturer shall submit to the certification agency a copy of the relevant standard(s), along with drawings, specifications, and other documents necessary to confirm compliance. The certification agency shall verify that all requirements of that standard are met.

4.2 Hydrostatic Strength

4.2.1 Plastic pipe shall meet the short-time failure (quick-burst) pressure specified in the appropriate recognized standard for its material and design. Where such a standard does not exist, a quick-burst pressure shall be determined from the equation:

$$log\ T = a - b\ log\ S$$

where a and b are constants, and using a value of $T = 0.1$ hours to obtain a corresponding stress value ($S_{0.1}$) and calculating a quick-burst pressure (QB) by the relation:

$$QB = (2 \times S_{0.1}) \div (SDR - 1)$$

The QB measured shall equal, at minimum, the pressure rating (PR) of the piping divided by a service factor (F) plus the surge pressure allowance (PS_{15}).

$$Minimum\ Requirement\ QB = (PR \div DF) + PS_{15}$$

The surge pressure allowance shall be that produced by a 15 ft/sec (4.6 m/sec) instantaneous velocity change and calculated per the relation:

$$PS_{15} = 927.6 \div [1 + (294{,}000 \times D_i)/(E \times t)]^{0.5}$$

where: PS_{15} = the surge pressure (psi) for that velocity change,
D_i = the nominal internal diameter of the pipe (in.),
E = the modulus of elasticity for the pipe material (psi), and
t = the nominal wall thickness of the pipe (in.).

The equivalent relation in SI units is:

$$PS_{15} = 6397 \div [1 + 2{,}027{,}070 \times D_i/(E \times t)]^{0.5}$$

with PS_{15} and E in units of kilopascals and D_i and t in units of millimeters.

Fittings shall not fail at lower pressure than pipe.

The intent of the requirement is that plastic piping possesses sufficient hydrostatic strength to prevent leakage or other failure over a 50-year service life.

4.2.2 At least one sample of each size pipe, fitting, and connection design shall be subjected to a 73°F (23°C) quick-burst hydrostatic test. In this test the internal pressure shall be raised from 0 to the minimum required pressure, QB, in not less than 60 and not more than 70 seconds. The pressure shall then be increased beyond the calculated minimum QB at the same rate of rise until failure occurs. The measured QB shall be recorded for use in evaluating the adequacy of the service factor.

4.3 Pressure Cycling

4.3.1 Piping shall withstand 100,000 cycles from 0 psi (0 kPa) to its 73°F (23°C) pressure rating at a frequency of one cycle every 5 to 10 seconds without leakage, separation, or permanent distortion. The intent of the requirement is that pressure fluctuations not loosen joints nor result in other creep-related failures.

4.3.2 Test samples shall be installed in the cycle pressure test apparatus described in Appendix A and cycled from 0 psi (0 kPa) to their 73°F (23°C) pressure rating, 175 psi (1205 kPa) minimum, at a frequency of one cycle every 5 to 10 seconds for 100,000 cycles. No leakage, joint separation, or permanent distortion shall result.

4.4 Impact Resistance

4.4.1 A 10 ft-lb (1.38 m-kg) impact shall not impair hydrostatic integrity of pipe, fittings, or joints. The intent of the requirement is that piping be resistant to minor impacts encountered in handling, installation, and service.

4.4.2 At least one sample assembly of each size pipe and "fitting type" submitted for certification, while resting across the narrow face of a length of nominal 2 x 3 standard construction lumber, shall be impacted with a 5 lb (2.27 kg) weight having a spherical impact nose as specified for a "B tup" in ANSI/ASTM D2444. The tup shall be dropped from a height of 2 ft. (0.61 m) once on the pipe wall, once on the "critical area" of each fitting, and once on the joint between the fitting and pipe. A "fitting type" is determined by inspection for the design of the various fittings submitted. For example, if wall thicknesses are identical, a 90° elbow and 45° elbow should be of the same "fitting type" and a test of a given size 90° elbow would suffice for the same size 45° elbow. Similarly, tees, reducing tees, and crosses are of the same "fitting type", as are couplings and reducers. The "critical area" of a fitting selected for impact is that area which would be the most vulnerable when the fitting is assembled to pipe. For most fittings this is the upper horizontal surface when the fitting joins horizontal pipes. Because of the difficulty in design of transition fittings, which connect the plastic piping to non-plastic piping or devices, all such fittings shall be subjected to the impact test.

4.4.3 Subsequent to undergoing impact tests, all samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.5 Crush Resistance

4.5.1 A 200 lbf (890 N) crushing load shall not impair hydrostatic integrity of pipe, fittings, or joints. All transition fittings shall be tested. The intent of the requirement is that plastic piping be resistant to minor crushing loads such as being stepped upon.

4.5.2 At least one sample assembly of each size pipe, fitting type, and joint shall be subjected to a 200 lbf (890 N) load for 10 seconds while retained between two pieces of nominal 2 x 3 standard construction lumber. The test configuration shall be per Appendix B. Subsequently, the tested sample(s) shall be examined for visible signs of collapse. If collapse is observed, a head loss test shall be conducted to measure the hydraulic effect. Head loss shall not be more than 5 percent greater than for equivalent, undamaged assemblies.

4.5.3 Subsequent to undergoing crush tests, all samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.6 High Ambient Temperature Exposure

4.6.1 A 45 day exposure of pipe, subjected to the hanger loadings resulting from the manufacturer's maximum spacing and minimum hanger width recommendations and at a temperature of 200°F (93°C) shall not result in a decrease in waterway area that would cause a flow reduction in excess of 5 percent at any supply

pressure from 10 to 175 psi (70 to 1205 kPa). The intent of the requirement is that piping installed in accordance with the manufacturer's instructions, shall not deform over time in such a manner as to degrade the hydraulics of the fire protection system.

4.6.2 At least one sample of each size pipe shall be assembled and mounted as indicated in Appendix C. The moment due to the anticipated weight of water-filled pipe per pipe hanger shall be calculated, based on the manufacturer's installation instructions. Half the weight required to produce that moment shall then be applied to each end of the test samples. The sample(s) shall then be placed in a 200°F (93°C) air environment for 45 days. Subsequently, the sample(s) shall be examined for collapsing of the waterway. If visible collapse has occurred, a head loss test shall be conducted to measure the effect of the reduced section. This data shall not be more than 5 percent greater than that obtained from uncollapsed pipe.

4.7 Sustained Pressure at Elevated Temperature

4.7.1 Piping shall sustain, at minimum, 90 percent of its 1000 h, higher rated temperature stress for a 45 day exposure period. All transition fittings shall be tested. The intent of the requirement is that piping submitted for tests demonstrate the applicability of the stress regression data submitted by the manufacturer in compliance with paragraph 3.3.1.

4.7.2 At least one sample of each size pipe submitted for evaluation shall be closed with the fittings of each connection design under evaluation and subjected to a constant internal pressure while maintained at 120°F (49°C) or its maximum pressure rating temperature (if higher). The pressurizing fluid shall be water and the external environment shall be air. The pressure level shall be calculated from the stress-regression equation derived in conformance with paragraph 3.3.1 using $T = 1000$ h. No failure shall occur throughout the 45 day duration of the test.

4.8 Cycling Ambient Temperature Exposure

4.8.1 Assemblies incorporating each size pipe, "fitting type", and joining method shall not separate, leak, or permanently deform when cycled between -40°F (-40°C) and their highest rated temperature once a day for ten days. The intent of the requirement is that piping maintains hydrostatic integrity when exposed to temperature fluctuations.

4.8.2 The minimum highest temperature to be used is 120°F (49°C). If the items under examination are pressure rated at a higher temperature, that temperature shall be used instead of 120°F (49°C). Unpressurized sample pipe and fitting assemblies shall be exposed to a -40°F (-40°C) environment from 6 to 18 hours. The environment shall then be elevated to the higher rating temperature, 120°F (49°C) environment for the remainder of the 24 hours. The entire sequence shall be repeated ten times. If the test is not run on ten consecutive days, the samples shall remain at -40°F (-40°C) during the idle time.

4.8.3 Subsequent to undergoing the cycling temperature exposure test described above, the samples shall be conditioned at 73°F (20°C) for a period of not less than 24 hours and then subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.9 Vibration

4.9.1 Piping joints shall withstand 30 hours of vibration at the amplitudes and frequencies specified below. No separation, leakage or other failure shall occur. Each joining method submitted shall be evaluated. The intent of the requirement is that piping joint integrity not be degraded by vibration found in building structures

4.9.2 Sample assemblies, as depicted in Appendix D, shall be subjected to a vibration of 0.02 in. (0.5 mm) amplitude at a varying frequency ranging from 18 to 37 Hz for a period of 5 hours while internally pressurized to their 73°F (23°C) rated pressure. The cycle period shall be 25 ± 5 seconds. If one or more resonant points can clearly be detected, the assemblies shall be vibrated at that frequency or frequencies for periods of the remaining 25 hours of the test proportionate to the number of resonant frequencies discovered.

If no resonant frequency is detected, then tests shall be conducted at the amplitudes, frequencies, and time periods noted in Table 4.9. At minimum, this test shall be conducted on nominal 1 in. assemblies.

Table 4.9 Vibration Test Conditions

Amplitude		***Total Displacement***		***Frequency***	***Time***
in.	***(mm)***	***in.***	***(mm)***	***Hz***	***Hours***
0.010	(0.25)	0.020	(0.51)	28	5
0.020	(0.51)	0.040	(1.04)	28	5
0.075	(1.90)	0.150	(3.81)	28	5
0.020	(0.51)	0.040	(1.04)	18 to 37 (variable)	5
0.035	(0.89)	0.070	(1.78)	18 to 37 (variable)	5

For this test, the amplitude is defined as the maximum displacement of sinusoidal motion from a position of rest to one-half of the total vibration machine table displacement.

4.9.3 Subsequent to undergoing the vibration test described above, the samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.10 Head Loss (Resistance to Flow)

4.10.1 Head loss measurements shall be conducted on pipes for which a Hazen-Williams "*C*" value of more than 150 is claimed. Such a test is also required of pipe for which no generally accepted "*C*" value exists. Fittings providing clear waterways of at least the inside diameter of the pipe need not be tested for flow restriction. Fittings having less than the full nominal size waterway shall be tested and the results expressed in terms of equivalent lengths of pipe of the same nominal diameter as the inlet of the fitting. These values shall not exceed those listed in NFPA l3D (in Table labeled “Equivalent Length in Feet of Fittings and Valves for Schedule 40 Steel Pipe”) by more than 5 percent. The intent of the requirement is that head losses of piping be known for the hydraulic calculation design of sprinkler systems.

4.10.2 Pipe requiring a head loss test shall be subjected to various flows and the loss of pressure over a 10 ft. (3.05 m) length measured. This loss shall be used in the Hazen-Williams friction loss formula to calculate a "*C*" value. That value shall substantially agree with that published by the manufacturer. If substantial disagreement with published values is found or if no published values exist, then the "*C*" value determined by test shall be listed.

Fittings having a waterway, when assembled to pipe, of less than that of the same nominal size pipe shall be flow tested to determine their actual head loss. This loss information shall be included in the listings of the fittings to assist system hydraulic calculations, if greater than 5 percent in excess of those tabulated in NFPA 13D.

4.11 Damage Resistance

4.11.1 Scratches and abrasions of depths equal to 10 percent of the wall thickness shall not cause hydrostatic failure of pipe. The intent of the requirement is that plastic piping shall maintain hydrostatic integrity when sustaining scratches and other minor damage likely to be regarded as superficial by the installer or user.

4.11.2 A representative size shall be selected for testing. Typically, three 1 in. nominal diameter samples shall be tested. Samples shall consist of pipe segments 10 nominal diameters long between fittings. Each end shall be provided with either a pressurization or a venting connection. Two samples shall be scratched with a single edge razor blade to a depth equal to one tenth of the nominal wall thickness. One sample shall be scratched perpendicularly to the axis of the pipe. This scratch shall be at full depth only at its center. The second sample shall be scratched parallel to its axis. This scratch shall be at full depth for a length equivalent to one nominal pipe diameter. The ends of the scratch shall be angled at no more than 45 degrees to the surface of the pipe. The bottom of both scratches shall be perpendicular to the diameter of the pipe.

The surface of the third sample shall be hand filed by an amount equal to one tenth of the nominal wall thickness, in an area no longer than one nominal pipe diameter. The filed surface shall be flat and perpendicular to the diameter of the pipe.

Scratched and abraded areas shall be located approximately centrally on the samples. Appendix E illustrates the three sample configurations.

4.11.3 Subsequent to undergoing the damage resistance test described above, the samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.12 Bending Moment Resistance

4.12.1 The external loads imposed on piping as a result of normal installation geometry shall not impair hydrostatic integrity. The intent of the requirement is that piping shall resist the bending loads caused by its weight and hanger spacing.

4.12.2 Each size of pipe and connection design shall be tested. The sample arrangement and test configuration is illustrated in Appendix F.

The required force (F_B) is determined by the relation:

$$F_B = w(S^2 - L^2) \div (2L)$$

Where: F_B = force required in test (lb.)
w = weight per foot of the water filled pipe (lbs.)
S = maximum hanger spacing (ft.), and
L = span between end supports in the test set-up (ft.).

4.12.3 While constantly under the bending load so determined, the samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.13 Tolerance for Enforced Bends

4.13.1 If the manufacturer's installation instructions permit piping to be installed with enforced bends, those bends shall not impair hydrostatic integrity. Each size of pipe shall sustain a "quick-burst" hydrostatic test while held in an enforced bend of the minimum radius permitted in the manufacturer's installation instructions, without violating its service factor.

4.13.2 Test samples shall be assembled with a pressurization or venting connection at each end. Samples shall be of sufficient length to describe a 90 degree arc at the minimum bending radius specified plus an additional 20 nominal pipe diameters of length. A structure of nominal 2x4 construction lumber shall be assembled to force the pipe into the bend and hold it in that position during test. Three points of restraint shall be maintained. The 2x4's shall contact the pipe at the center, inside of the bend, and the outer outside ends of the bend. Lateral restraint shall be provided to prevent the pipe from moving along the 2x4's. The points of contact shall be corners of the 2x4's, rather than their flat surfaces.

4.13.3 While positioned as described above, the samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.14 Thermal Expansion and Contraction

4.14.1 The maximum tensile force produced by a temperature decrease of 100°F (56°C) acting on a length of pipe equal to the maximum hanger spacing shall be imposed on sample piping. No violation of the pressure rating factor of safety shall result. Plastic piping typically exhibits large thermal expansion coefficients. The restraints imposed by installation hanging and fixing result in axial forces in piping when temperature changes occur. The intent of this requirement is that such forces shall not impair the hydrostatic integrity of the system.

4.14.2 Representative test samples shall be selected. Typically, a sample shall consist of two segments of pipe, each three feet (1 m) long, joined in the center to a fitting, and provided with a pressurization or venting connection at each end. A constant axial tension force (F_t) shall be imposed on the sample throughout the test. This force is calculated by the relation:

$$F_t = \pi \times (d \times t - t^2) \times E \times a \times \Delta T$$

Where: F_t = tensile force due to temperature,
d = pipe outside diameter,
t = pipe wall thickness,
E = modulus of elasticity (units of Force per Area),
a = thermal coefficient of expansion (units of length per unit length per thermal degree), and
ΔT = temperature change, 100°F (56°C).

While under its appropriately calculated F_t, each sample shall be subjected to a "quick-burst" hydrostatic test. The results shall be assessed as described in paragraph 4.4.3.

4.14.3 While under its appropriately calculated F_t, as described above, the samples shall be subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.15 Ultraviolet (UV) Resistance

4.15.1 Plastic pipe shall not exhibit a decrease in hydrostatic integrity, below that accounted for by the safety factor, as a result of exposure to a combined 96 hours of UV “B” and condensation. Piping, prior to installation, may be stored outdoors. UV “B” radiation in sunlight causes degradation of plastics. The intent of this requirement is that such degradation shall not impair the ability to join the pipe and/or fittings nor its subsequent hydrostatic integrity.

4.15.2 A minimum of six pipe samples of a representative size shall be selected. Typically, samples of the nominal 1 in. size 1 ft. (0.3 m) long shall be used. Samples shall be rinsed in water and wiped dry with paper towels. Samples shall then be installed in a fluorescent UV “B” condensation type weathering apparatus, as described in ASTM G154. Ultraviolet "B" fluorescent lamps shall be used. (UV "B" radiation is the most destructive component remaining in sunlight reaching the earth's surface). Exposure duration shall be 96 hours with a continuously repeated cycle of 8 hours of UV “B” and 4 hours of condensation. The cabinet temperature shall be 145°F (63°C) during the condensation portion.

4.15.3 After exposure to the UV “B” radiation described above, the samples shall be allowed to cool to ambient temperature, dried, and then joined to end fittings providing pressurization or venting connections and subjected to a "quick-burst" hydrostatic test. Failure pressures shall not be less than their rated pressure (PR) plus the allowance for surge (PS_{15}), calculated as described in paragraph 4.2.1. Failure pressure data shall be used to test the adequacy of the service factor as described in section 4.17.

4.16 Permanence of Markings

4.16.1 Normal handling and weathering shall not render markings illegible. Markings shall be water and oil resistant.

4.16.2 Representative samples of pipe and fittings shall be selected. Samples shall be subjected to water immersion for 5 minutes per day for 10 days. After each sample is removed from the water each day, it shall be rubbed vigorously on the marked surface with paper towels. Marking shall not smear, bleed, or deposit residue on the towels. After the conclusion of the 10 days of water exposure testing, the samples shall be covered with petroleum-based grease and remain undisturbed for 24 hours. After that time has elapsed, the grease shall be removed from the samples by wiping with paper towels. Vigorous rubbing of the marked surface shall not result in smearing, bleeding, or other removal of markings. Molded or embossed markings need not be subjected to this test.

4.17 Service Factor

4.17.1 Adverse conditions shall not reduce the pressure capacity of the piping by more than that accounted for by the service factor. A maximum service factor of 0.5 shall be allowed on hydrostatic design for the pressure rating of the pipe under all conditions of service.

4.17.2 The result of the hydrostatic tests of paragraph 4.2 shall be termed the "base-line quick-burst pressure": (QB_b) for a given size. The lowest result for a given size from the tests of sections 4.4, 4.5., 4.8, 4.9, 4.11, 4.12, 4.13, 4.14, or 4.15, whichever is the lowest, shall be termed the "impaired quick-burst pressure" (QB_i). The relation:

$$F = (QB_i - PS_{15}) \div (QB_b - PS_{15})$$

where PS_{15} is the surge pressure allowance for an instantaneous water velocity change of 15 ft/sec (4.6 m/s), shall be used to calculate a service factor (F) for each size. The least of these calculated F's shall be identified. If that F is less than 0.5, then it shall be used to recalculate the hydrostatic design basis (HDB) for both rating temperatures by the relation:

$$HDS = HDB \times F$$

and a corresponding new pressure rating for the pipe shall be calculated for both rating temperatures as follows:

$$PR = (2 \times HDS) \div (SDR - 1)$$

where PR is the pressure rating, and SDR is the dimension ratio of the pipe.

Certification shall be limited to a new PR, so derived. A product having a PR less than 175 psi (1205 kPa) cannot be certified.

4.18 Chemical Compatibility Test for Environmental Stress Cracking between Plastic Piping Products and Steel Sprinkler Pipe with Antimicrobial (AMC) and/or Antibacterial Coatings/Films

If one of the intended uses of the plastic pipe and fittings is in hybrid sprinkler systems using internally coated steel pipe (*i.e.* plastic pipe connected to internally coated steel pipe), evaluation of plastic pipe and fittings under this standard shall include chemical compatibility testing with all certified manufacturer applied internally coated steel pipe (*i.e.* internally coated by the manufacturer) in accordance with Appendix G.

4.18.1 When exposed to a solution of deionized (DI) water and the extract from Antimicrobial (AMC) or Antibacterial coated steel pipe, Type V tensile specimens of plastic pipe shall experience neither an average reduction of more than 20 percent in Tensile Stress at Yield nor an average reduction of more than 50 percent in Elongation at Break when compared to unexposed control specimens. There shall be no cracks or crazes visually observable on the tensile surface and edges of exposed specimens for all specified exposure periods. Results of this testing will be reported as PASS or FAIL in the applicable test documentation. When testing is required for compatibility with plastic fittings only, special considerations will be given to the shape of the test samples and will be determined by the certification agency at the time

of project initiation.

4.18.2 Testing shall be performed in accordance with Appendix G.

4.19 Additional Tests

At the discretion of the certification agency, additional tests may be required, depending on design features, results of any tests, material application, or to verify the integrity and reliability of the pipe and/or fittings.

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

5. PERFORMANCE REQUIREMENTS - EXPOSED

In addition to the requirements outlined in section 4 of this standard, plastic piping that is to be certified for exposed service must also meet the performance requirements of the fire test, as defined in section 5.1, 5.2 or 5.3.

5.1 Fire Test 1 – Universal Application

A simulated branch line consisting of representative samples of the plastic pipe and fittings submitted for certification shall be exposed to a 60 minute fire exposure with a uniform heat flux of 125 kW/m^2 (+/- 5%). The fire exposure test allows for a maximum of 10 minutes, after the initiation of the fire, for the measured heat flux to achieve and maintain the required 125 kW/m^2 (+/- 5%). This 10 minute ramp-up time is included as part of the 60 minute exposure time. The heat exposure source fire shall be a propane gas diffusion flame. A water flow of 15 gpm (58 L/min) at 7 psi (48 kPa) shall be flowing through the simulated branch line for the duration of the test. If no damage, distortion or thermal deformation to the plastic pipe or fittings that would impair the operation of the sprinkler or sprinkler system is observed the water flow through the branch line is stopped. The branch line shall then be hydrostatically tested to its rated working pressure, increasing pressure at a rate of less than 5 psi/sec (35 kPa/sec), for 2 minutes. No water leakage from the simulated branch line is allowed.

5.2 Fire Test 2 – Restricted Application

A simulated branch line consisting of representative samples of the plastic pipe and fittings submitted for certification shall be exposed to a two step fire exposure starting with a uniform heat flux of 100 kW/m^2 (+/- 5%) for 15 minutes immediately followed by a uniform heat flux of 50 kW/m^2 (+/- 5%) for 45 minutes. The heat source fire shall be a propane gas diffusion flame. A water flow of 15 gpm (58 L/min) at 7 psi (48 kPa) shall be flowing through the simulated branch line for the duration of the test. If no damage, distortion or thermal deformation to the plastic pipe or fittings that would impair the operation of the sprinkler or sprinkler system is observed the water flow through the branch line is stopped. The branch line shall then be hydrostatically tested to its rated working pressure, increasing pressure at a rate of less than 5 psi/sec (35 kPa/sec), for 2 minutes. No water leakage from the simulated branch line is allowed.

5.3 Fire Test 3 – Hazard Category 1 Application

A simulated branch line consisting of representative samples of the plastic pipe and fittings submitted for certification shall be exposed to a two step fire exposure starting with a uniform heat flux of 50 kW/m2 (+/- 5%) for 1 minute immediately followed by a uniform heat flux of 25 kW/m2 (+/- 5%) for 59 minutes. The heat exposure source fire shall be a propane gas diffusion flame. A waterflow of 15 gpm (58 L/min) at 7 psi (48 kPa) shall be flowing through the simulated branch line for the duration of the test. If no damage, distortion or thermal deformation to the plastic pipe or fittings that would impair the operation of the sprinkler or sprinkler system is observed, the water flow through the branch line is stopped. The branch line shall then be hydrostatically tested to its rated working pressure, increasing pressure at a rate of less than 5 psi/sec (35 kPa/sec), for 2 minutes. No water leakage from the simulated branch line is allowed.

6. OPERATIONS REQUIREMENTS

6.1 Demonstrated Quality Control Program

6.1.1 A quality assurance program is required to assure that subsequent products produced by the manufacturer shall present the same quality and reliability as the specific products examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

6.1.2 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-conforming materials

6.1.3 Documentation/Manual

There shall exist an authoritative collection of procedures/policies. It should 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.

6.1.4 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed for a minimum of two years from the date of manufacture.

6.1.5 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 certification report may be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

6.2 Surveillance Audit

6.2.1 An audit of the manufacturing facility is part of the certification agencies surveillance requirements to verify implementation of the quality assurance program. Its purpose is to ensure that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

6.2.2 Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted

at any other location prior to disclosure to the certification agency.

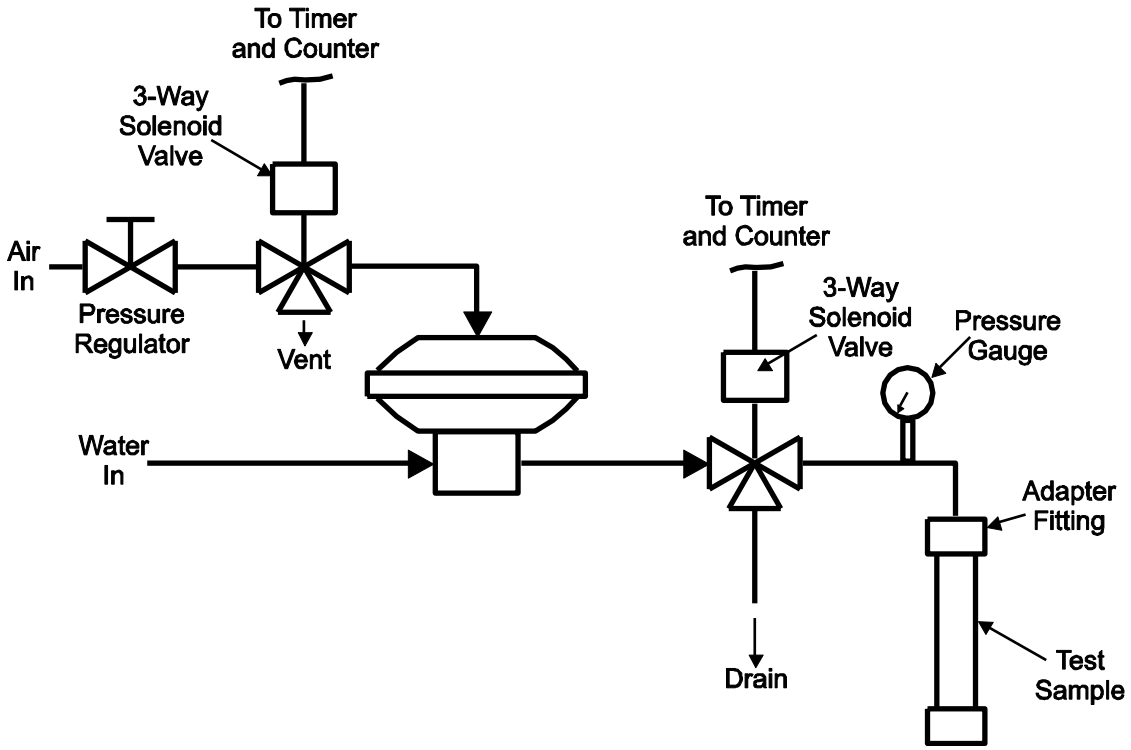
6.3 Manufacturer's Responsibilities

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

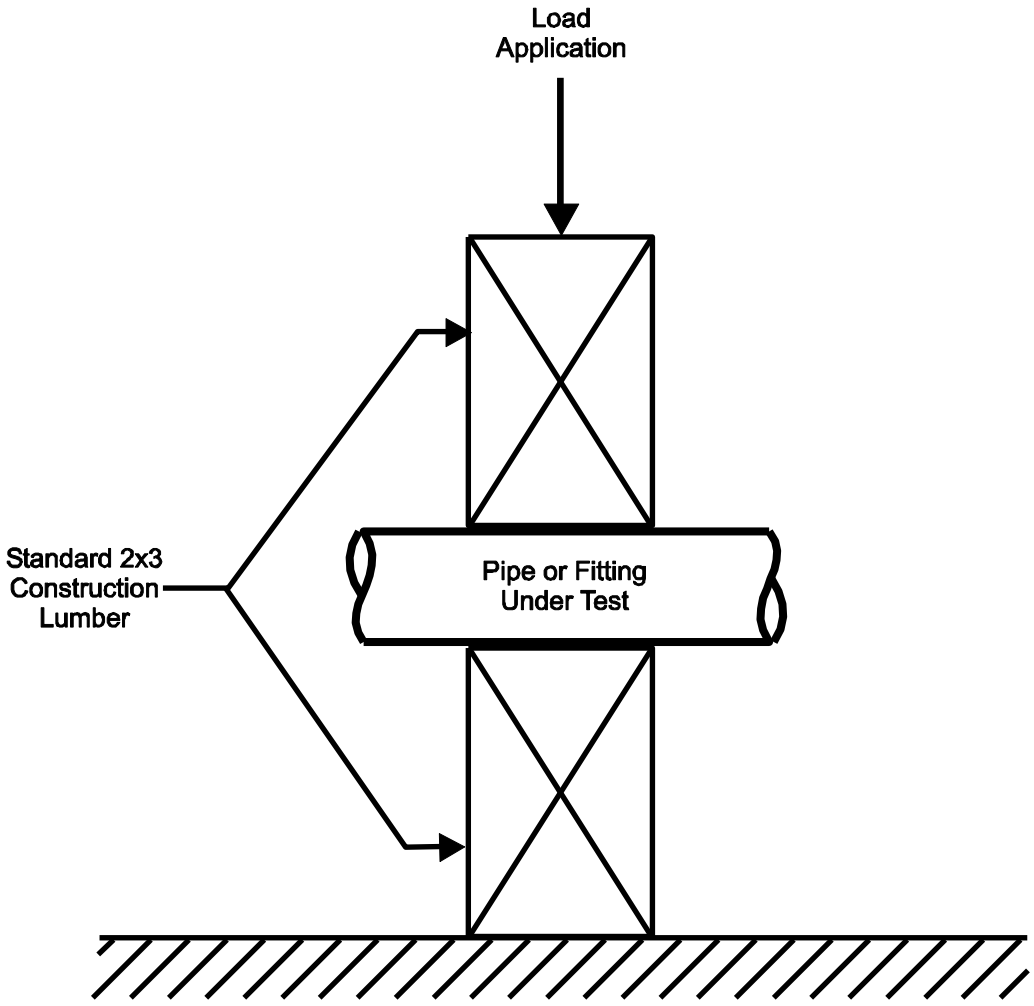
6.4 Manufacturing and Production Tests

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 the 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.

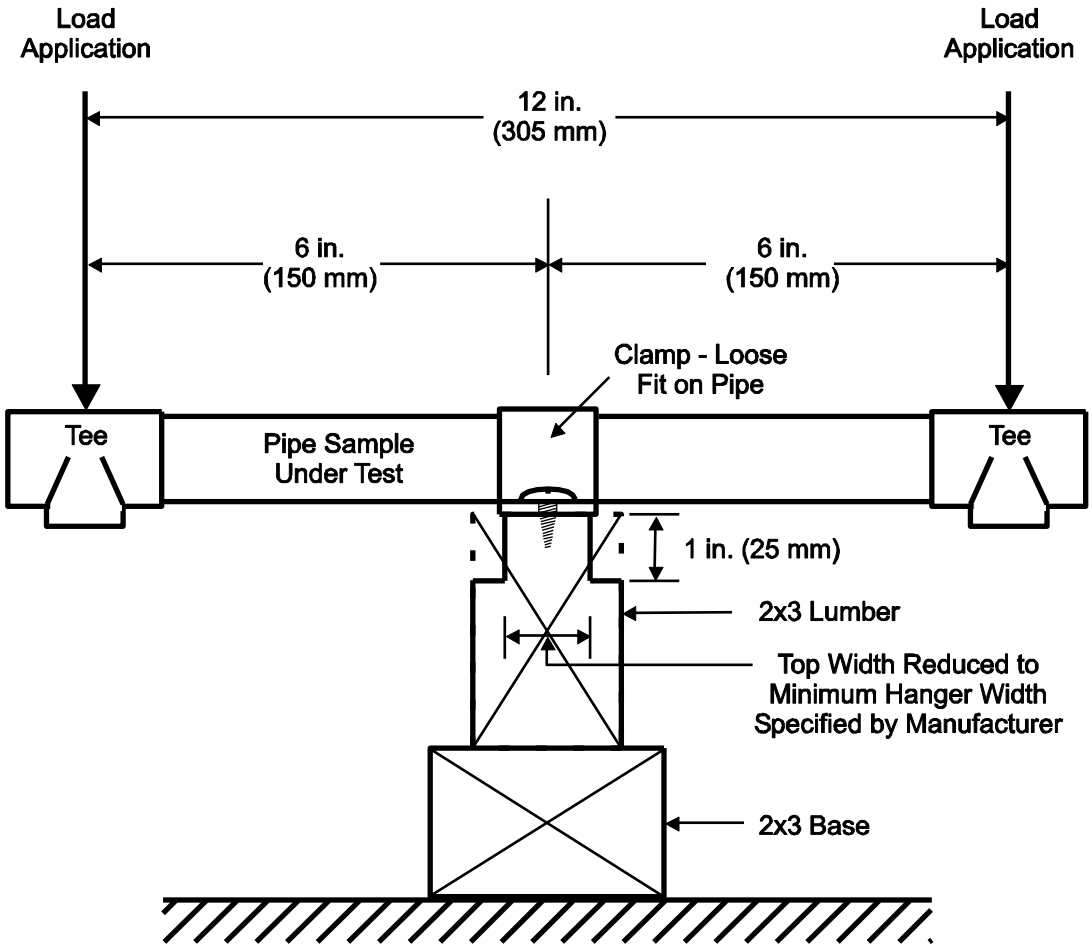
APPENDIX A: Pressure Cycling Test Apparatus Configuration



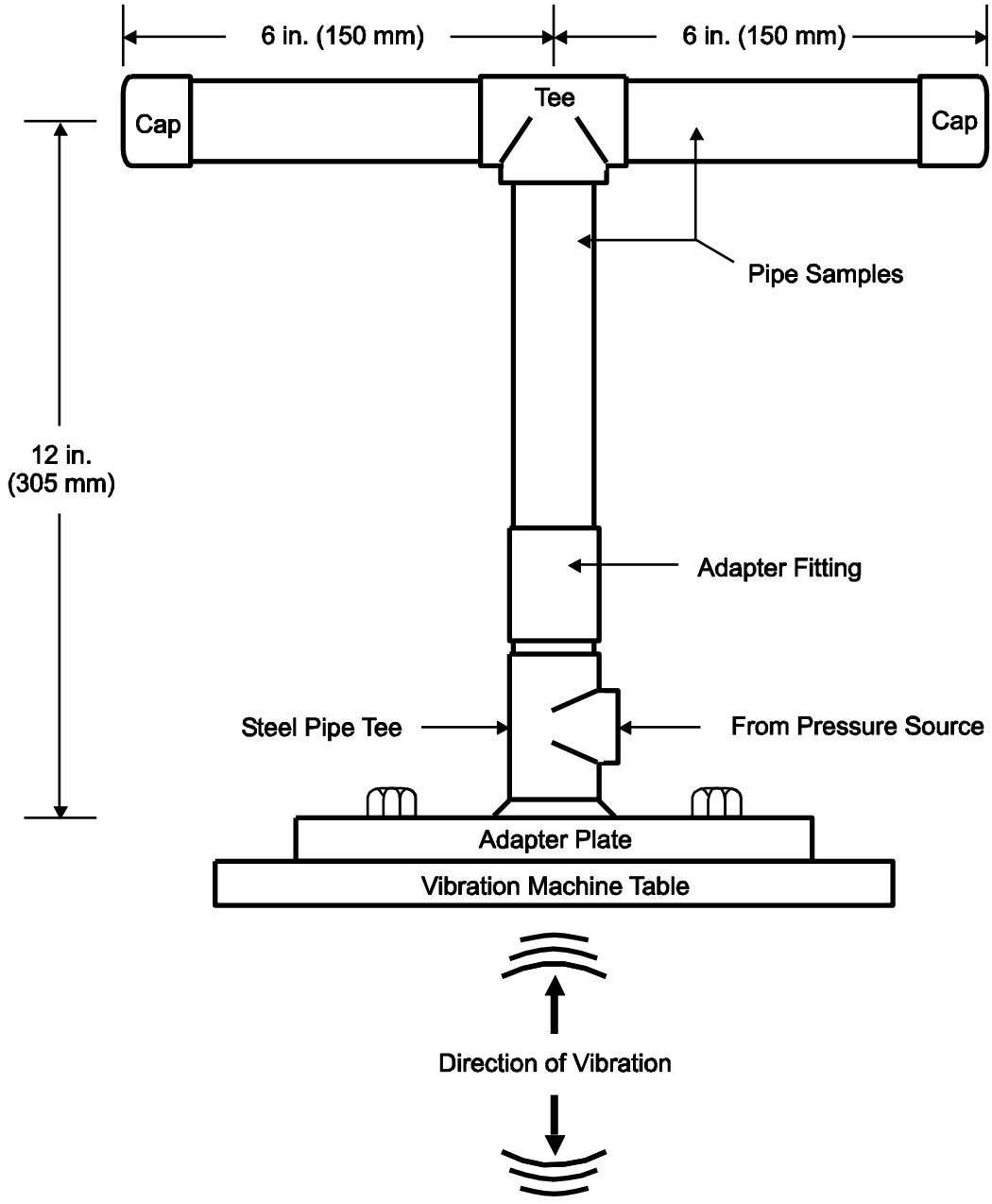
APPENDIX B: Crush Resistance Test Sample Configuration



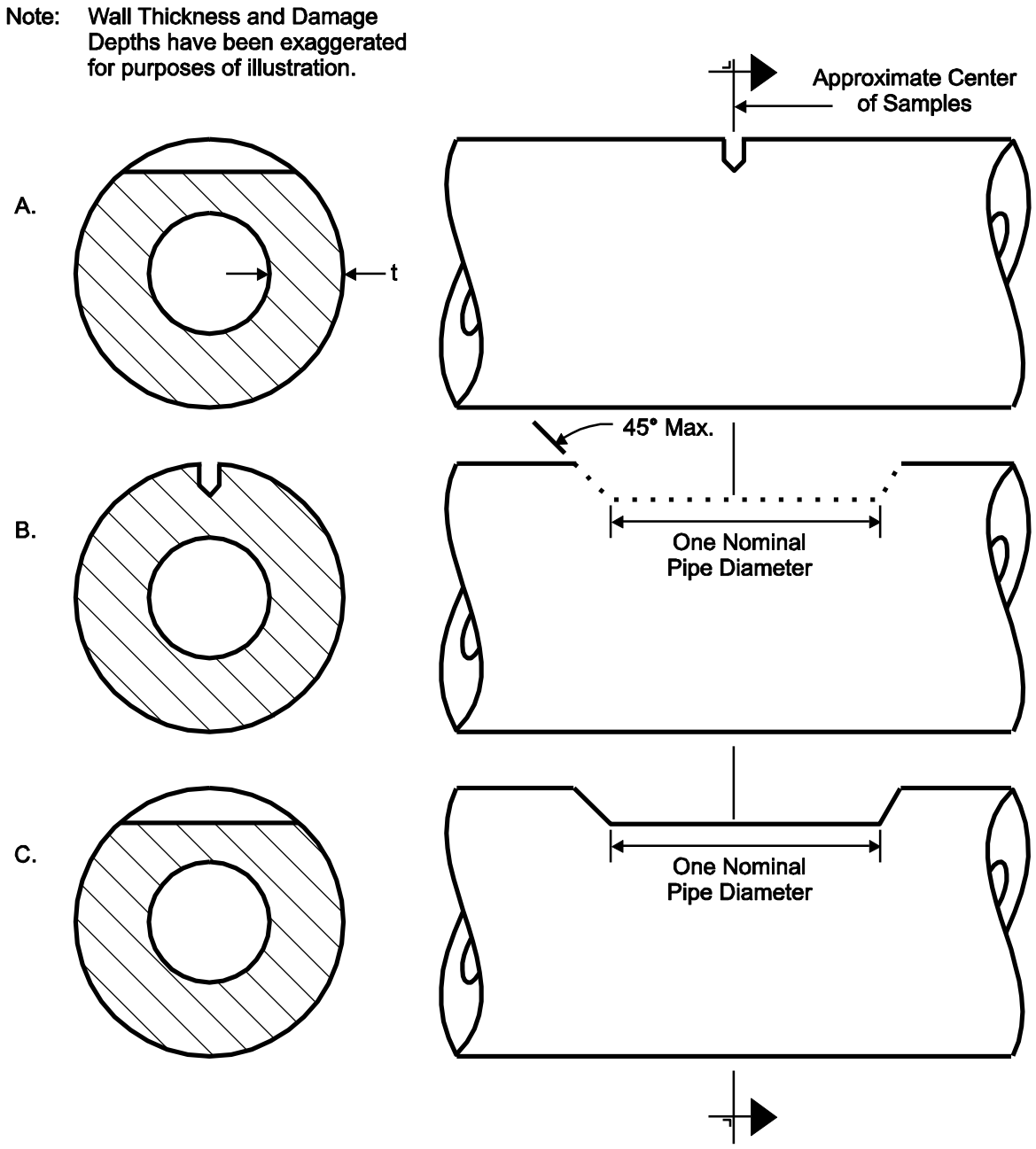
APPENDIX C: High Ambient Temperature Sample Configuration



APPENDIX D: Vibration Test Sample Configuration

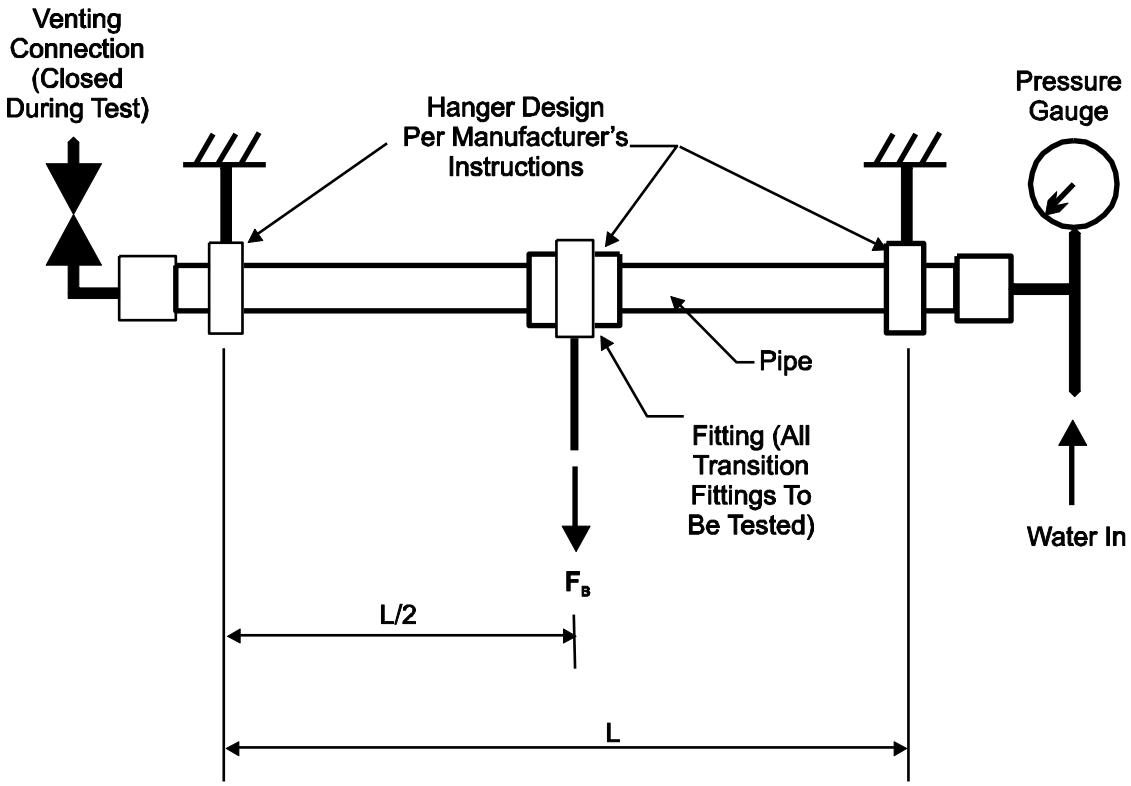


APPENDIX E: Damage Resistance Test Samples



A. Scratch perpenducular to axis.
B. Scratch parallel to axis.
C. Filed area perpendicular to axis.

APPENDIX F: Bending Moment Resistance Test Configuration



APPENDIX G: Chemical Compatibility Test Protocol

Chemical Compatibility Test for Environmental Stress Cracking between Plastic Piping Products and Steel Pipe with Antimicrobial (AMC) and/or Antibacterial Coatings/Films

If one of the intended uses of the plastic pipe and fittings is in hybrid sprinkler systems (i.e. plastic pipe connected to internally coated steel pipe), evaluation of plastic pipe and fittings under this standard shall include chemical compatibility testing with all certified manufacturer applied internally coated steel pipe (i.e. internally coated by the manufacturer) in accordance with Appendix G.

Requirement

When exposed to a solution of deionized (DI) water and the extract from Antimicrobial (AMC) or Antibacterial coated steel pipe, tensile Type V specimens of plastic pipe shall not experience an average reduction of more than 20 percent in Tensile Stress at Yield nor an average reduction of more than 50 percent in Elongation at Break when compared to unexposed control specimens. There shall be no cracks or crazes visually observable on the tensile surface of exposed specimens for all exposure periods. Results of this testing will be reported as PASS or FAIL in the applicable test documentation. When testing is required for compatibility with plastic fittings only, special considerations will be given to the shape of the test samples and will be determined by the certification agency at the time of project initiation.

Test/Verification

Deionized (DI) water shall be used to extract antibacterial or antimicrobial coatings from the inside surfaces of all currently certified steel sprinkler pipe with Antimicrobial (AMC) or Antibacterial Coatings/Films in accordance with the following procedure:

- Place a cut section of 2 mil (0.002 in.) thickness Teflon® PTFE film on one end of a 5 ft (1.52 m) long 3 in. (75 mm) NPS piece of coated pipe.
- Cover the Teflon® PTFE film with a 3 in. (75 mm) rubber end cap, and fit an end cap on the end of the pipe.
- Tighten the hose clamp on the rubber end cap to prevent water leakage.
- Place the pipe in the upright position, with the sealed cap located at the bottom.
- Pour five liters of DI water into the open end of the pipe.
- Seal the open end of the pipe with a second section of Teflon film and a second rubber end cap/hose clamp.
- Place the pipe horizontally on a suitable apparatus that will allow constant rotation of the pipe for a period of 10 days at a rotation rate of 44 +/- 2 revolutions per minute (RPM).
- At the completion of the 10 day extraction period, remove the DI water extract from the pipe and collect for subsequent exposure testing of CPVC / plastic pipe samples.

Type V Tensile Specimens shall be machined from 1 inch (25 mm) NPS chlorinated polyvinyl chloride (CPVC per ASTM F442) or other plastic pipe (polypropylene per ASTM F2389) being considered for certified in hybrid fire sprinkler systems with steel pipes with antimicrobial or antibacterial coatings.

- For illustration, the dimensions of Type V tensile specimens are shown in Figure G-1 for a 1 inch (25 mm) NPS specimen of CPVC plastic pipe made in accordance with ASTM F442. Dimensions of the Type V-tensile specimens may vary based on pipe thickness. The fabrication of Type V tensile specimens is to be in accordance with ASTM D638.
- Due to the limited dimensions of 1 inch (25 mm) NPS CPVC pipe, and potentially other plastic pipes, it is necessary to machine the length of 2.500 inch tensile specimen along the longitudinal axis of the 1 inch (25 mm) NPS CPVC or other plastic pipe as shown in Figure G-2 for fabrication of the Type V tensile specimens.
- The cut edges of the machined surfaces shall be made smooth by finishing with No. 320 or finer sandpaper.

- A minimum of five Type V tensile specimens mounted on an appropriately sized strain jig in accordance with ASTM D543 (1 percent for CPVC pipe in accordance with ASTM F442) shall be tested for each condition.

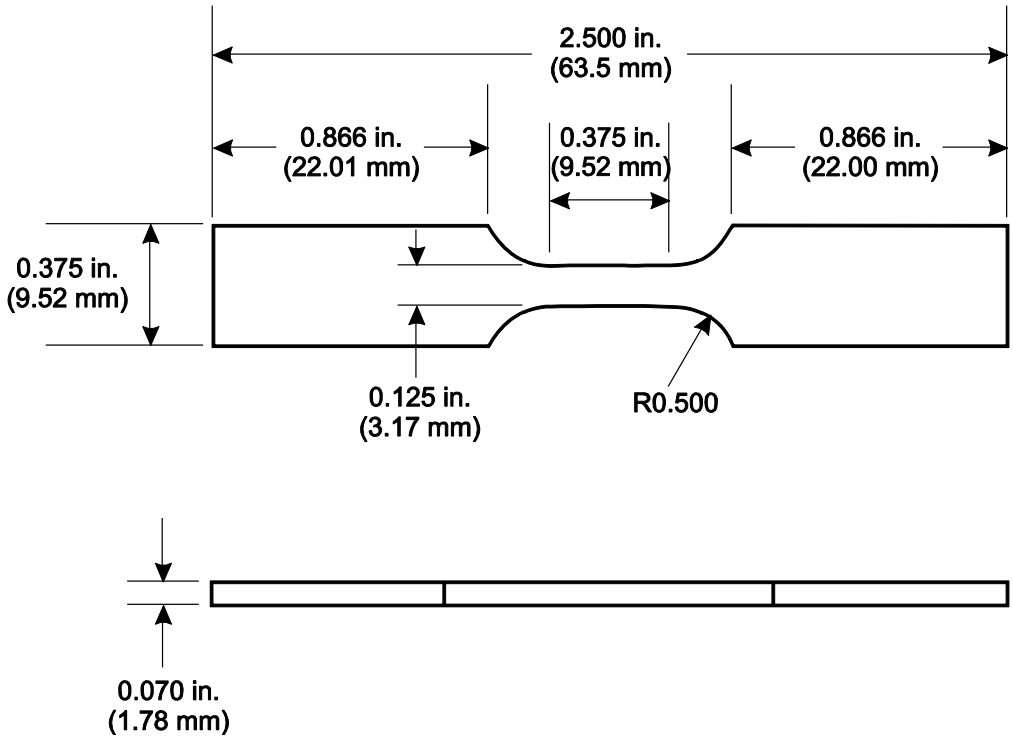


Figure G-1 – Schematic drawing for dimensions of Type V tensile specimens in accordance with ASTM D638 of 1 inch (25 mm) NPS CPVC in accordance with ASTM F442 (units in inches)

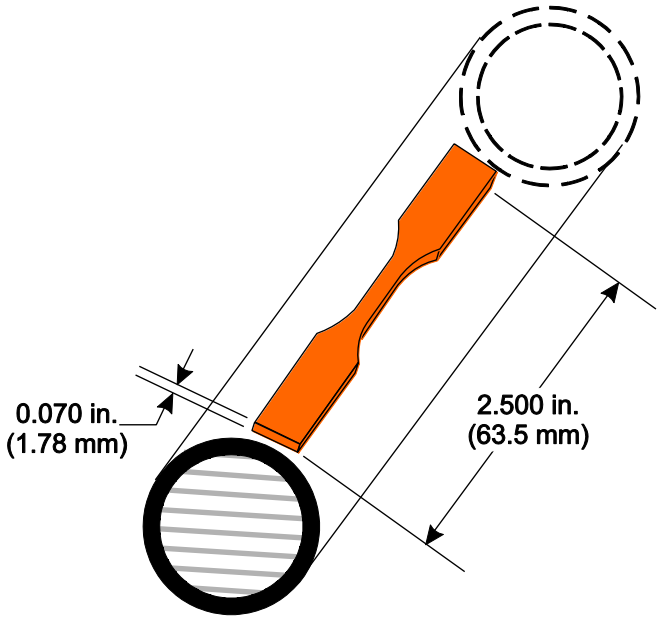


Figure G-2 – Schematic drawing for the machining direction of the Type V tensile specimen in accordance with ASTM D638 of 1 inch (25 mm) NPS CPVC pipe in accordance with ASTM F442 (units in inches)

Strain fixture operation and tensile properties' measurements shall be conducted in accordance with the following procedure.

- Mount 5 Type V tensile specimens on an appropriately sized strain fixture in accordance with ASTM D543 (1 percent for 1 inch (25 mm) NPS CPVC pipe per ASTM F442). Ensure that at least 0.7 in. (18 mm) of close contact along every specimen's gage length and fixture surface is maintained, and specimens do not touch each other. It should be noted that the top surface of the Type V tensile specimen mounted on the strain fixture shall be the inside surface (water side) of the CPVC / plastic pipe.
- Prepare four sets of mounted strain fixtures for each type of DI water extract exposure. Three sets of strain fixtures are used for exposure testing and one set is used to test as the control sample (i.e. DI exposure only).
- Place the mounted strain fixture in a glass jar with 13.5 oz (400 ml) of the DI water extract, and ensure that the fixtures are fully immersed in the extract for test periods of 1 week, 2 weeks, and 4 weeks.
- To ensure good chemical contact between Type V tensile specimens and the DI water extract throughout exposure period, the liquid in the glass containers should be stirred once daily during the first week of exposure and once each week subsequently.
- After 1 week, 2 weeks, and 4 weeks of exposure, remove the applicable exposed Type V tensile specimens from the strain fixtures and measure the tensile properties in accordance with ASTM D638. After 1 week of exposure, remove the unexposed control specimens and measure the tensile properties in accordance with ASTM D638.
- Test specimens within 24 hours after being removed from the strain fixture.
- The nominal strain rate in tensile test shall be 1 mm/min (0.039 inch/min) for all exposure conditions in order to have a consistent testing speed throughout the tests.
- Average value with Standard deviation shall be calculated for the sample size of 5 test samples.

All specimens shall pass the acceptance criteria as shown below:

- State of surface: There shall be no cracks or crazes visually observable on the tensile surface and edges of exposed specimens for all specified exposure periods. Results of this testing will be reported as PASS or FAIL in the applicable test documentation.
- Tensile Strength at Yield: There shall be less than 20 percent reduction in the average value of the Tensile Strength at Yield for exposed specimens vs. unexposed control specimens for all specified exposure periods. Results of this testing will be reported as PASS or FAIL in the applicable test documentation.
- Elongation at Break: There shall be less than 50 percent reduction in the average value of the Elongation at Break for exposed specimens vs. unexposed control specimens. Results of this testing will be reported as PASS or FAIL in the applicable test documentation.