Member of the FM Global Group

Examination Standard for Steel Pipe for Automatic Fire Sprinkler Systems

Class Number 1630

June 2021

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.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Purpose

1.1.1 This standard states testing and certification requirements for steel pipe for use in aboveground fire sprinkler systems.

1.1.2 Testing and certification criteria may include, but are not limited to, 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 applies to the design and performance requirements for steel pipe for use in aboveground fire sprinkler systems.

1.2.2 This standard is limited to NPS (Nominal Pipe Size 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 5, 6, 8, 10 and 12 steel pipe. Note that NPS 1/2 pipe, for example, may be referred to as 1/2 in NPS, or 1/2 in pipe. Larger sizes of steel pipe may be evaluated on a case-by-case basis. Certification of NPS 1/2 and 3/4 pipe is permitted for use as valve trim, gauge connections, and for other peripheral service. Certification for use in aboveground fire sprinkler systems is limited to steel pipe NPS 1 through 12. The waterflow path of the sprinkler system cannot be designed using pipe smaller than NPS 1. In cases where metric sized steel pipe is to be examined, test criteria comparable to the equivalent for nearest nominal diameter (DN) size shall be used (Refer to Table 1.2.7).

1.2.3 Steel pipe may be certified under this standard for use in either wet or dry pipe sprinkler systems, or both, but in all cases for aboveground service only.

1.2.4 If the steel pipe includes a manufacturer-applied internal coating and is intended for use in a hybrid sprinkler system (*i.e.,* plastic pipe connected to internally-coated steel pipe), evaluation of the internally-coated steel pipe under this standard shall include chemical compatibility testing with all certified plastic pipe and fittings (Refer to Appendix I).

1.2.5 This standard encompasses steel pipe manufactured by the furnace welded, continuous butt-weld, or electric resistance welded process. Other methods of manufacturing, such as spiral welded, or seamless pipe may be evaluated under this standard as long as the intent of this standard is met.

1.2.6 This standard encompasses "Specialty Tubulars" for use with mechanical press connections. Like Schedule 5 steel pipe, "Specialty Tubulars" are limited for use in branch line service, but only after a transition fitting from steel pipe. These "Specialty Tubulars" are limited to sizes NPS 1 through 2 when manufactured in carbon steel, and NPS 1 through 4 when manufactured in stainless steel.

1.2.7 For comparison between the outside diameters (OD) of pipes manufactured to ASME B36.10M dimensions, and those of other standards, the following table, Table 1.2.7 has been made for reference.

Table 1.2.7 Pipe OD Comparison Chart

Nominal Pipe Size		***Nominal Outside Diameter***	
NPS	***DN***	***in***	***mm***
1/2	15	0.840	21.3
3/4	20	1.050	26.7
1	25	1.315	33.4
1 1/4	32	1.660	42.2
1 1/2	40	1.900	48.3
2	50	2.375	60.3
2 1/2	65	2.875	73.0
3 OD	-	3.000	76.1
3	80	3.500	88.9
3 1/2	90	4.000	101.6
4 1/4 OD	-	4.250	108.0
4	100	4.500	114.3
5 1/4 OD	-	5.250	133.4
5 1/2 OD	-	5.500	139.7
5	125	5.563	141.3
6 1/4 OD	-	6.250	158.8
6 1/2 OD	-	6.500	165.1
6	150	6.625	168.3
8 (JIS)	200A	-	216.3
8	200	8.625	219.1
10 (JIS)	250A	-	267.4
10	250	10.750	273.0
12 (JIS)	300A	-	318.5
12	300	12.750	323.8

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 steel pipe for the purpose of obtaining certification. Steel pipe having characteristics not anticipated by this standard may be certified if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met.

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; 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 may be made 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 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, but is not limited to, the following based upon 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;
- satisfactory field experience;
- 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 agencies 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 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. 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.

ANSI/AWWA C606 - 2015, *Standard for Grooved and Shouldered Joints*

ANSI/ASME B1.20.1 - 2013, *Pipe Threads, General Purpose (Inch).*

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

ASME B36.10M - 2018, *Welded and Seamless Wrought Steel Pipe*

ASTM A53/A53M - 20, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A123/A123M – 17, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.*

ASTM A135/A135M - 20, *Standard Specification for Electric-Resistance -Welded Steel Pipe*

ASTM A795/A795M - 13, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*

ASTM D543-20, *Standard Specification for Evaluating the Resistance of Plastics to Chemical Reagents*

ASTM D638-14, S*tandard Test Method for Tensile Properties of Plastics*

ASTM F442-20, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*

BS EN 10255:2004, *Non-Alloy Steel Tubes Suitable for Welding and Threading – Technical Delivery Conditions*

ISO 65 - 2012, *Carbon Steel Tubes Suitable For Screwing in Accordance with ISO 7/1*

ISO 7-1 – 3rd Edition (2007), *Pipe threads where pressure-tight joints are made on the threads -- Part 1: Dimensions, tolerances and designation*

JIS G3454 - 2017, *Carbon Steel Pipes For Pressure Service*

1.9 Terms and Definitions

For purposes of this standard, the following terms apply:

Accepted

Installations acceptable to the authority having jurisdiction and enforcing the applicable installation rules (Authority Having Jurisdiction). Acceptance is based upon an overall evaluation of the installation. Factors other than the use of certified equipment impact upon the decision to accept the product. Acceptance is not a characteristic of a product, it is installation specific. A product accepted for one installation may thus not be acceptable elsewhere.

Agency

A certification agency or test agency.

Bundle

This term refers to the commonly accepted method of packaging and shipping pipe. Predetermined quantities of pipe lengths are grouped together and banded for shipment. The manufacturer shall indicate on the dimensional drawings or specifications the actual number of pipes per bundle, per nominal pipe size. It is important to note that although the phrase is common in industry, the actual count of pipe lengths may vary from one manufacturer to another.

Corrosion Resistant

Steel pipe shall be termed corrosion resistant if its interior surface exhibits equivalent resistance to aqueous corrosion as steel pipe which is internally coated with zinc by the hot-dip process to a weight of no less than 1.8 oz/ft^2 (0.55 kg/m^2).

Cut Groove

A groove that is cut into the outside diameter of a pipe or fitting near the end to allow its joining by means of a gasketed, split, grooved pipe coupling.

End Connections

The method of connecting components of a pipe system. Typical end connections in fire protection service are cut groove, rolled groove, threaded, plain end, and welded end.

Lightwall Pipe

Lightwall pipe is characterized by having a combination of outside diameter and wall thickness not suitable for cut grooving or threading. Lightwall pipe shares the same outside diameter dimensions as Schedule 40 pipe; however the wall thickness of Lightwall pipe ranges between that of Schedule 5 and 10 and can vary from manufacturer to manufacturer. The normal end connections for Lightwall pipe are: welded, rolled groove, and plain end. This pipe is also commonly referred to in industry as “Flow” pipe or “Schedule 7" pipe. There is no national or international standard for this product at this time.

Master Coil

For the cases where steel is supplied to the pipe mill in coiled form, the original wide coil is referred to as the master coil. If the steel is supplied pre-slit, then each slit coil shall be identified to retain material traceability to the master coil.

Mechanical Press Connection

A mechanical connection that joins Specialty Tubulars to a metallic fitting with an elastomeric seal with the use of a pressing tool. The joint is created when the Specialty Tubular is inserted into the metallic fitting past the seal, and then mechanically joined using the pressing tool.

Pipe Schedule

The commonly accepted reference indicating a specified wall thickness for a given nominal pipe size. Traditional pipe Schedules were derived on a largely empirical basis and do not represent truly proportional design. Generally, smaller sizes are much thicker in proportion to diameter than larger sizes. This is because mechanical considerations predominate in smaller sizes, and pressure carrying capacity predominates in larger sizes.

Plain Ended Pipe

Pipe with ends cut perpendicular to its axis and incorporating no grooves or threads on either end.

Pressure Rating

The pressure rating assigned to a product as a part of the certification process. The minimum pressure rating considered for certification is 175 psi (1205 kPa). The pressure rating of an assembly is that of its lowest pressure rated component.

Rolled Groove

A groove pressed into the surface of a pipe or fitting near the end to allow joining by means of a gasketed, split, grooved pipe coupling. For clarity, the definition used in this Standard is for grooves that start from the outside diameter of the pipe, and project radially inward towards the pipe axis. Not to be confused with shouldered pipe that may be formed on similar equipment.

Schedule 40 Pipe

Schedule 40 pipe refers to a historically accepted combination of outside diameter and wall thickness that has been subsequently published in national standard ASME B36.10M. Other national and international standards also make reference to Schedule 40 pipe but may or may not reflect the same dimensions for a given nominal pipe size. Therefore, certification of pipes manufactured under the specifications of other national or international standards must be specified using the title of the standard and the dimensions for outside diameter and wall thickness. For the purposes of this certification standard, dimensional values of Schedule 40 pipe and pipes of similar outside diameter and wall thickness have been listed in Appendix E. Certified end connections are threaded, welded, rolled or cut groove, or plain end.

Schedule 30 Pipe

Schedule 30 pipe refers to a historically accepted combination of outside diameter and wall thickness that has been subsequently published in national standard ASME B36.10M. Other national and international standards also make reference to Schedule 30 pipe but may or may not reflect the same dimensions for a given nominal pipe size. Therefore, certification of pipes manufactured under the specifications of other national or international standards must be specified using the title of the standard and the dimensions for outside diameter and wall thickness. For the purposes of this certification standard, dimensional values of Schedule 30 pipe have been listed in Appendix E. Certified end connections are welded, rolled groove, or plain end.

Schedule 10 Pipe

Schedule 10 pipe refers to a historically accepted combination of outside diameter and wall thickness that has been subsequently published in national standard ASME B36.10M. Other national and international standards also make reference to Schedule 10 pipe but may or may not reflect the same dimensions for a given nominal pipe size. Therefore, certification of pipes manufactured under the specifications of other national or international standards must be specified using the title of the standard and the dimensions for outside diameter and wall thickness. For the purposes of this certification standard, dimensional values of Schedule 10 pipe have been listed in Appendix E. Certified end connections are welded, rolled groove, or plain end.

Schedule 5 Pipe

Schedule 5 pipe refers to a historically accepted combination of outside diameter and wall thickness that has been subsequently published in national standard ASME B36.10M. Other national and international standards also make reference to Schedule 5 pipe but may or may not reflect the same dimensions for a given nominal pipe size. Therefore, certified of pipes manufactured under the specifications of other national or international standards must be specified using the title of the standard and the dimensions for outside diameter and wall thickness. For the purposes of this certification standard, dimensional values of Schedule 5 pipe have been listed in Appendix E. Certified end connections are welded, rolled groove* and mechanically swaged fittings and are limited to sizes NPS 1 through 2. Schedule 5 pipe is not suitable for certified bolted-style plain end fittings. (* - Limited certification of rolled grooved connections. Refer to the listings of the pipe couplings or fittings for specific mention of their suitability for use with Schedule 5 pipe.)

Shouldered Pipe

Pipe with mechanical shoulders that are cast, welded, or mechanically formed on the outside diameter of the pipe. For clarity, the definition as used in this Standard refers only to shoulders that start at the pipe outside diameter, and extend radially outward from the pipe axis.

Specialty Tubulars

Specialty Tubulars refer to the collection of pipe and tube products that are used to make mechanical press connections that are not defined by the other defined classifications of pipe/tube product included within this standard such as: Schedules 40, 30, 10, or 5; Thinwall Pipe; or Lightwall Pipe. The outside diameter of the tubular product may coincide with that of either pipe or tubes made to other national or international standards. For the purposes of this standard, the tubular product shall have a minimum wall thickness nearly equal to that of Schedule 5 pipe. Submittal information must include reference to the industry standard used in production of the Specialty Tubular product, and the dimensions for outside diameter and wall thickness. Specialty Tube may be certified with mechanical press style couplings and fittings only. (Refer to listings for mechanical press style couplings and fittings that make specific mention of their suitability for use with Specialty Tubulars.)

Threaded Pipe

Pipe which has been furnished with its end(s) threaded with external pipe threads conforming to national or international standards for pipe threads such as ANSI/ASME B1.20.1, ISO 7-1, etc.

Thinwall Pipe

Thinwall pipe is characterized by having a combination of outside diameter and wall thickness suitable for threading but not suitable for cut grooving. Thinwall pipe dimensions are not addressed in any current national of international standard. Thinwall pipe typically is manufactured using outside diameter dimensions equivalent to those used on Schedule 40 pipe. However, the actual outside diameter dimensions may vary from that of Schedule 40 pipe and may vary from manufacturer to manufacturer. Pipe wall thickness range between those of Schedules 10 and 40 and may vary from manufacturer to manufacturer. The normal end connections for Thinwall pipe are: threaded, rolled groove, welded, or plain end. There is no national or international standard for this product.

Welding End

Steel pipe furnished with welding ends is characterized by having the ends cut perpendicular to its axis and finished with a pronounced bevel on each end to allow for butt-welding.

2 GENERAL INFORMATION

2.1 Product Information

2.1.1 Steel pipe has been effectively used in fire sprinkler systems since its introduction in the nineteenth century. However, evolution in pipe specifications, materials, and production technology impairs the direct correlation of this successful service history to that to be expected from newer products. Further, some evidence exists that some products currently available in the field do not meet all the criteria of the commonly-accepted standards for steel pipe. This may result from the tact that some standards contain no enforcement mechanisms except those agreed upon between manufacturer and purchaser. In addition, pipe designs exist which do not match the Schedules traditionally used in fire protection. For these reasons, the certification agency has established this standard for steel pipe.

2.1.2 In order to meet the intent of this standard, steel pipe 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 using identical materials by different manufacturers, or even different plants of the same manufacturer, have been seen to perform differently in testing. Sample steel pipe, selected in conformance to this criterion, shall satisfy all of the requirements of this standard.

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, complete set of manufacturing drawings, materials list, anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and number and location of manufacturing facilities;
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3 Requirements for Samples for Examination

2.3.1 Following authorization of a certification examination, the manufacturer shall submit samples for examination and testing based on the following:

- Sample requirements to be determined by the certification agency.

2.3.2 Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3 The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of the certification agency.

2.3.4 It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate the steel pipe.

2.3.5 In addition to the sample requirements, manufacturers submitting samples of Lightwall, Thinwall, or Schedule 5 steel pipes; or Specialty Tubulars, are also required to advise the certification agency in writing of the manufacturer and model numbers of the couplings and/or fittings to be used in the evaluation. The pipe manufacturer shall also obtain and submit a letter from the coupling/fitting manufacturer to allow the addition of the pipe usage reference in the coupling/fitting manufacturer’s listing pending successful completion of the examination testing.

3 GENERAL REQUIREMENTS

3.1 Review of Documentation

3.1.1 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 certification examination results may further define the limits of the final certification.

3.1.2 The manufacturer's dimensional specifications and/or dimensional drawings shall fully describe the product. All critical dimensions shall be indicated with the allowed upper and lower tolerances clearly shown.

3.1.3 All documents pertaining to the product materials, dimensions, processing, and marking shall be controlled by the manufacturer's Quality Assurance procedures, 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 tran

3.2 Physical or Structural Features

3.2.1 Pipe shall be designed for a minimum rated working pressure of 175 psi (1205 kPa) for use in fire protection systems. Pipe may be evaluated based on a higher-pressure rating at the manufacturer's option.

3.2.2 Installation of black steel pipe is limited to wet pipe sprinkler systems only. Coatings shall be evaluated on a case-by-base basis, as they may require special test methods and test equipment.

3.2.3 Installation of galvanized pipe is permitted in dry pipe (including preaction) sprinkler systems only. The galvanized pipe shall have an average minimum coating thickness of 1.8 oz/ft^2 (0.55 kg/m^2). Steel pipe with a galvanized coating shall be evaluated in accordance with ASTM A123/A123M.

3.2.4 Steel pipe with internal coatings that would allow for installations in either wet or dry pipe sprinkler systems shall be evaluated on a case-by-case basis, as they may require special test methods and test equipment.

3.2.5 Certification examinations of galvanized pipe shall include performance testing using a representative sampling of grooved end couplings and/or pipe fittings. Threaded end connections shall be in accordance with ANSI/ASME B1.20.1, BS 21, ISO 7-1 or other recognized national or international standards for their country of use.

3.2.6 Grooved and shouldered end connections shall conform to the dimensional requirements of ANSI/AWWA C606. Alternatively, grooved or shouldered end connections specified in the manufacturer's literature, or to another recognized national or international standard shall be evaluated by the certification agency on a case-by-case basis.

3.2.7 Pipes manufactured with either plain or welding ends shall conform to a recognized national or international standard.

3.2.8 Other types of end connections may be evaluated on a case-by-case basis. Refer to definitions, Section 1.9, for normal end connections for Schedule(s) 40, 30, 10, and 5, Thinwall, and Lightwall steel sprinkler pipe, and Specialty Tubulars.

3.2.9 Pipe samples submitted for testing shall be true production samples and shall be free of sharp edges, burrs, or other imperfections that might injure the test technician or interfere with proper assembly of the test assembly.

3.2.10 Manufacturers shall exhibit their ability to trace material back to the individual master coils and obtain mechanical and physical properties from the steel mill for each master coil used in the production of certified pipe. Production pipe shall be marked with a manufacturing date reference in the form of: production code, heat number, date and shift code, or run number at the manufacturer's option. Other methods may be acceptable and will be reviewed on a case-by-case basis

3.2.11 Installations for Schedule 5 pipe and Specialty Tubulars are limited to branch line service and are subject to maximum hanger spacing of 12 ft (3.6 m) for the allowed sizes. Specialty Tubulars have an additional requirement to be installed downstream of a transition fitting that makes the connection from traditional steel pipe to the Specialty Tubular system in order to maintain system integrity.

3.3 Materials

3.3.1 All materials used in the fabrication of these pipes shall be suitable for the intended application. Raw material shall be evaluated in accordance with the appropriate sections of the manufacturer's Quality Assurance Manual plus any applicable national and/or international standards.

3.3.2 Examples of suitable materials are included in the standards ASTM A53/A53M, ASTM A135/A135M and ASTM A795/A795M.

3.4 Markings

3.4.1 Each length of pipe shall be permanently and continuously marked with the following minimum information:

- Manufacturer's name or trademark;
- Pipe size and nominal length;
- Schedule or model reference;
- Rated working pressure;
- National or international standard (including grade reference) to which the pipe was manufactured;
- Manufacturing source code, where necessary;
- Heat number or master coil reference number, or a date and shift code;
- Production test reference (NH, Test Pressure, NDE, etc.); and,
- The certification agency's mark of conformity

3.4.2 Markings shall be painted, inked, or laser printed on the outside surface of each length of pipe at regular repeating intervals. The spacing between the end of one complete marking and the start of the next shall not exceed 12 inches (300 mm).

3.4.3 Any additional pertinent marking information required by the national or international standard to which the pipe is manufactured shall be permanently marked on the outside surface of each length of pipe.

3.4.4 Each required marking listed in Section 3.4.1 shall be legible and durable and shall be applied in any of, or any combination of, the above methods.

3.4.5 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product the certification agency's mark of conformity.

3.4.6 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.

3.5 Minimum Wall Thickness

The certification agency has established minimum pipe wall thickness values, shown in Table 3.5 that shall be maintained after threading or cut grooving of steel sprinkler pipe. For reference, the datum points at which the minimum wall thickness is defined for each end connection are: under the first exposed thread, and at a minimum cut groove diameter (including tolerance) as applicable. Pipe that exhibits a wall thickness less than these values at their respective localized areas shall be subjected to long term corrosion tests. Pipe that has a continuous wall thickness less than these values, due to the manufacturing process, or due to the pipe Schedule requirements, shall not be acceptable. Pipe designed in accordance with SI unit standards shall be of the minimum thickness values in the nearest corresponding U.S. customary pipe sizes unless otherwise noted in this standard. A sample calculation that illustrates the pipe thickness under the first exposed thread is show in Appendix G.

Table 3.5 Minimum Wall Thicknesses

Nominal Pipe Size	***Nominal Diameter***	***Minimum Wall Thickness***	
NPS	***DN***	***in***	***(mm)***
1/2	15	0.035	(0.89)
3/4	20	0.039	(0.99)
1	25	0.044	(1.12)
1-1/4	32	0.050	(1.27)
1-1/2	40	0.054	(1.37)
2	50	0.057	(1.45)
2-1/2	65	0.065	(1.65)
3	80	0.073	(1.85)
3-1/2	90	0.080	(2.03)
4	100	0.086	(2.18)
5	125	0.099	(2.51)
6	150	0.110	(2.79)
8	200	0.134	(3.40)
10	250	0.159	(4.04)
12	300	0.183	(4.65)

3.6 Manufacturer's Installation and Operation Instructions

Identification tags, final Quality Control acceptance tags, and Installation Instructions, including any special dimension requirements, shall be furnished by the manufacturer, and provided in each bundle of pipe.

3.7 Calibration

3.7.1 Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of 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 provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.7.2 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 are allowed, provided documentation is maintained on the calibration status of thus equipment.

4 PERFORMANCE REQUIREMENTS

4.1 Examination

4.1.1 The steel pipe shall conform to the manufacturer's drawings and specifications and to certification requirements.

4.1.2 A sample shall be examined and compared to drawings and specifications. It shall be verified that the sample conforms to the requirements described in Section 3, General Requirements.

4.2 Hydrostatic Strength

4.2.1 Pipe shall be able to withstand an internal hydrostatic pressure equal to four times the rated working pressure without cracking, rupture, or permanent distortion.

4.2.2 Compliance shall be verified by testing a minimum of one assembly of each size and Schedule of pipe submitted for certification. The testing shall address each size of pipe, and the corresponding allowed joining methods. This testing may be performed using multiple joints along the same pipe, or for individual assemblies for each joining method. Pipe segments between test joints shall be approximately 1 ft (0.3 m) long each. Pipe assemblies shall be subjected to a hydrostatic test of a minimum of 700 psi (4830 kPa), or four times the rated working pressure, whichever is greater. Each hydrostatic pressure test shall be conducted for a duration of five minutes. The test pressure for each assembly incorporating a certified fitting or coupling and length of pipe shall be four times the lowest rated working pressure of any component of the assembly. The certification agency and the manufacturer shall jointly agree on the fittings and couplings to be used in the test assemblies. Figure C-1, in Appendix C, illustrates the required test configuration for a single joint assembly.

4.3 Bending Moment Resistance

4.3.1 Assemblies fabricated using the same joining methods, and tested under Section 4.2.2 above, shall demonstrate bending moment resistance, without leakage or fracture, at the moment specified in Appendix E. The bending moment resistance shall be demonstrated while the test assembly is internally pressurized to the rated working pressure of the pipe or fitting, 175 psi (1205 kPa) minimum. The test assemblies shall also address each nominal size of pipe under consideration for certification.

4.3.2 Compliance shall be verified by testing an assembly fabricated using each joining method, centered between two lengths of pipe. There shall be a separate assembly for each size and/or wall thickness of pipe under consideration. The outer ends of the assemblies shall be suitably capped and provided with pressurization and venting connections. Each assembly shall be supported in a test fixture, with the joint of interest centered on that span. Force shall be applied to the center of the joint, which will act to deflect the assembly until the minimum required bending moment is reached. Bending moments shall be demonstrated while the test assembly is pressurized to the rated working pressure of the pipe or fitting, 175 psi (1205 kPa) minimum. The bending moment tables in Appendix E list the required moments for a number of different common pipes, and three common sizes of bending moment fixtures. It is not necessary to test at each listed support spacing.

4.3.3 These moments have been calculated from the weights of water-filled pipe, with a maximum hanger spacing allowed for sprinkler systems (assuming that one hanger is missing), and a safety factor of two. Currently, NPS 1-1/4 (DN32) and smaller is installed with a maximum hanger spacing of 12 ft (3.6 m). Larger sizes of installed pipe allow hangers no greater than 15 ft (4.6 m) apart. Lighter schedules of pipe shall be tested to these values on the assumption that a hybrid system can be installed, joining Schedule 40 pipe to thinner walled pipe, which allows for the possibility that the Schedule 40 load could be imposed upon the joint in the thinner walled pipe. If the installation rules allow for hanger spacing greater than that upon which these values have been based for a particular

Schedule, size, or type of pipe, the bending moment required values shall be recalculated taking the revised hanger spacing into account. An example of bending moment calculations has been illustrated in Appendix D. Pipe designed in accordance with SI unit standards shall withstand bending moments as listed in Appendix E, or as calculated for the project, based on customary installation rules of the national standard of the country of manufacture.

4.3.4 For pipe manufactured to specifications that do not define pipe “Scheduled”, for example the German standard DIN EN 10220 as well as the Chinese Standard GB/T 3091, the certification test loads shall be calculated based on a range of pipe thicknesses. This is to account for the change in weight as a result of the variances in pipe wall and waterway volume.

4.3.5 There are no bending moment values for NPS 1/2 (DN15) and 3/4 (DN20) pipe as they are only used in accessory lines. Figure C-2 illustrates the required test configuration for pipes NPS 1 (DN25) and larger pipe.

4.3.6 The only exceptions to Schedule 40 bending moments are Lightwall pipe, Schedule 5 pipe and Specialty Tubulars. Schedule 5 pipe and Specialty Tubulars are limited to use exclusively in branch line service. Bending moments for Schedule 5 pipe are based on water filled Schedule 40 pipe, and 12 ft (3.6 m) hanger spacing independent of nominal pipe size. Bending moments for Specialty Tubulars are based on Schedule 5 bending moment loads for the transition fitting connection, and calculated based on the actual Specialty Tubular dimensions for downstream connections. Bending moments for Lightwall pipe are based on a hybrid system comprised of water filled Schedule 40 pipe and Schedule 10 pipe, and traditional hanger spacings for a given nominal pipe size.

4.3.7 There shall be no leakage, cracking, or coupling separation as a result of this test.

4.4 Rotational Bending Moment Resistance

4.4.1 Pipe shall maintain local structural integrity when used with certified mechanical saddle-like fittings, or with welded branch outlet fittings. The maximum permitted outlet size is one pipe size less than the run size. Each tee-shaped assembly shall be subjected to a rotational bending moment, which acts to rotate the fitting around the centerline of the run pipe, and coplanar with the pipe axis, while the run pipe is secured. When mechanical saddle-like tee fittings are designed to be assembled in a cross-configuration, the rotational bending moment shall be applied to the cross configuration, in lieu of the tee configuration. The rotational bending moment resistance shall be demonstrated while the test assembly is internally pressurized to the rated working pressure of the pipe or fitting, 175 psi (1205 kPa) minimum.

4.4.2 Compliance shall be verified by testing assemblies of each nominal pipe size under consideration for certification. The test assemblies shall be composed of each nominal pipe size, and certified saddle-like fittings of the corresponding largest permitted branch size. The run pipe shall be held rigidly, and a force shall be aligned to the branch pipe sufficient to apply the rotational bending moment shown in Appendix F, based upon branch line size. Figure C-3 illustrates the suggested test configurations for both directions of testing. The assembly shall be internally pressurized to its rated working pressure throughout the test. There shall be no leakage, cracking, rupture or pipe deformation as a result of this test. Separate test assemblies may be supplied by the manufacture for the two tests.

4.4.3 When an applied rotational bending moment causes a fitting or coupling to rotate (slip) around the run pipe without reaching the required torque value, the fitting shall be allowed to rotate through 90° of travel, moving the run pipe in the test fixture as necessary. Before, during, and after the 90° rotation, the fitting or coupling shall remain leak tight while pressurized to its rated working pressure regardless of whether or not the required bending moment is achieved.

4.5 Vibration Resistance

4.5.1 Pipe joints of all acceptable and certified types shall withstand the effects of vibration without deterioration of their performance characteristics. Following the vibration test detailed in Section 4.5.2, the joint shall not leak when tested in accordance with Section 4.2 (Hydrostatic Strength).

4.5.2 Compliance shall be verified by testing a minimum of one sample assembly of each type appropriate to the pipe under examination. The test sample configuration is illustrated in Figure C-4. The assembly shall be hydrostatically pressurized to 80 psi (550 kPa) during the entire test and shall be subjected to the vibration sequence of Table 4.5.2; each 5-hour test increment shall be run continuously. The plane of vibration shall be vertical. No leakage or other failure is allowed during the 25 hour test. Subsequently, the hydrostatic test of Section 4.2 shall be repeated after the vibration test of each sample assembly. No leakage or other failure shall be observed.

Table 4.5.2 Vibration Test Conditions

Test No.	***Total Stroke***		***Frequency Hz***	***Time Hours***
	in	***(mm)***		
1	0.020	(0.51)	28	5
2	0.040	(1.04)	28	5
3	0.150	(3.81)	28	5
4	0.040	(1.04)	18 to 37 (variable)	5
5	0.070	(1.78)	18 to 37 (variable)	5

4.6 Marking Durability

4.6.1 Pipe markings shall remain legible under conditions of storage, transport and handling to allow identification of the product.

4.6.2 Compliance shall be verified by immersing an approximately 18 in (450 mm) long length of pipe, with clear markings, in water for five minutes once each day for 10 working days. After each sample is removed from the water each day, it shall be rubbed vigorously in the area of the markings with a cotton or paper towel. Markings shall not smear, bleed, or deposit residue on the towels. After the conclusion of the 10 days of water exposure testing, the markings on the sample 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 cotton or paper towels. No bleeding, smearing, or other removal of the pipe markings shall occur.

4.7 Corrosion-Resistant Coatings

4.7.1 Corrosion-resistant coatings, such as hot dip galvanized, shall exhibit even and continuous coverage, sufficient thickness, proper adhesion, and appropriate physical and chemical properties on the inner surface of the pipe.

4.7.2 For hot-dip galvanized coatings, compliance shall be verified by examining samples of internally coated pipe of each size submitted and conducting tests in accordance with ASTM A123. The samples shall be cut from a full length of pipe after coating. A total of three samples shall be made from the two free ends and from the center of the full length of pipe. The samples shall be approximately 24 inch (600 mm) in length. Measurements shall be made at equally spaced points around the outside diameter, approximately 4 in (100 mm) from the end. A minimum of four measurements around the outside diameter are required for NPS 2 (DN50) pipes and smaller, and a minimum of six measurements are required for pipe larger than NPS 2 (DN50 size). The sample pipe shall exhibit an average coating thickness of 1.8 oz/ft^2 (0.55 kg/m^2), on each sample regardless of the standard to which it was made. The coating thickness shall not be less than 1.5 oz/ft^2 (0.46 kg/m^2) at any of the individual measured locations. Samples shall be shipped to the certification agency in such a manner to protect each specimen from damage during shipping.

4.8 Long-Term Corrosion Testing

4.8.1 After threading or cut grooving, pipes that exhibit a wall thickness below the values listed in Table 3.5 shall be evaluated by subjecting the pipes to a long-term corrosion test. These pipes will be subjected to a 200 week corrosion test to determine if the pipes exhibit corrosion rates in excess of the established rates for Schedules 10 and 40.

4.8.2 Samples shall be production samples drawn from a minimum of 14 different heats of raw material. These samples can be gathered over time to avoid special set-ups by the manufacturer.

4.8.3 Initial measurements of wall thickness and outside diameter dimensions of each pipe sample shall be made prior to starting the test program. Wherever possible, weld seams shall be oriented away from data locations. Pipe sections that are severely out of round shall not be used. All measurements shall be recorded in the Project Data Record, including the equipment calibration data, the location and orientation of wall thickness measurements, and how the pipe is to be marked to preserve that orientation throughout the test.

4.8.4 A minimum of 4 samples each from 14 different heats shall be threaded, each approximately 12 in (300 mm) in length, of NPS 1-1/4 and 2 (DN32 and 50) for the test assembly. In the event that these sizes are not normally produced, or not part of the test program, alternate sizes shall be agreed upon prior to the start of the test.

4.8.5 A quantity of 7 different heat samples of the 14 heats shall be assembled with straight couplings between manifold ends. Two similar arrays of each size are to be constructed. At least two additional samples from each heat of steel shall be set aside for dimensional reference at the conclusion of the test, or to provide a means to complete the test in the event of a failure. These two samples shall be kept covered during the test until needed.

4.8.6 Prior to the start of the test, the complete test row shall be internally pressurized to twice the rated working pressure for 5 minutes. No leakage is allowed.

4.8.7 On a weekly basis, the line pressure from each row of samples shall be drained. Stale water from the pipe is to be gently flushed, and the pipe refilled with fully oxygenated water. The pressure in the pipe is to be restored to line pressure, and the isolation valve closed. This process is to be repeated for each sample in the test array.

4.8.8 At the end of 150 weeks, if no leaks are evident, an ultrasonic inspection shall be made to determine if any corrosion treads can be observed. If necessary, the assembly will be disassembled for a more detailed examination of the individual pipe samples.

4.8.9 At the first sign of perforation or leakage, the pipe row where the leak occurred will be isolated. The outside of the assembly shall be examined to determine the cause for leakage. If necessary, the assembly will be drained and starting with the point of leakage, disassembled and inspected to determine if the leakage is caused by perforation of the pipe wall, or a leak at a joint. The pipe section(s) will be replaced with one of the replacement lengths mentioned in Section 4.8.5 (if necessary) and, the assembly reinstalled into the test apparatus.

4.8.10 At the end of 200 weeks of testing, if no failures have been experienced that cause the program to end, the test shall be terminated. The assemblies shall be disassembled and the pipes sectioned lengthwise and studied for evidence of tuberculation and/or pits in the pipe wall. The measurements shall include a tabular description of wall thickness loss and a discussion of the findings. As a condition of certification, the results shall be compared to the established rates of corrosion for Schedule 10 and 40 steel pipe to determine if the pipe under examination exhibits corrosion rates in excess of Schedule 10 and 40 steel pipes. Corrosion rates in excess of those established for Schedule 10 and 40 steel pipe shall constitute a failure.

4.9 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 internally-coated steel pipe is in hybrid sprinkler systems (*i.e.* internally-coated steel pipe connected to plastic pipe and/or fittings), evaluation of internally-coated steel pipe under this standard shall include chemical compatibility testing with representative samples of all certified plastic pipe and fittings in accordance with Appendix I.

4.9.1 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 reported as PASS or FAIL in the applicable test documentation. When testing is required for compatibility with plastic fittings only, special consideration will be given to the shape of the test samples and will be determined by the certification agency at the time of project initiation.

4.9.2 Testing shall be performed in accordance with Appendix I.

4.10 Corrosion Evaluation Test

If steel pipe is internally-coated with a material designed for both wet and dry sprinkler system installations, evaluation of internally-coated steel pipe under this standard shall include corrosion evaluation testing with representative samples in accordance with Appendix J.

4.10.1 The internal coating, when applied to the steel pipe under evaluation, shall meet all of the following requirements:

A. The corrosion rate (CRw) of the internally coated pipe samples after 3 month's exposure time shall be less than the corrosion rate of galvanized pipe after 3 month's exposure time.

B. The adhesion rate shall be greater than 800 psi (5.5 MPa) plus the standard deviation of the measurements taken.

C. The coating thickness shall not be less than a standard deviation of its nominal thickness.

D. The tensile surface and edges of the exposed specimens shall not exhibit any visually observable cracks or crazes after all specified exposure periods.

E. The average reduction of Tensile Strength at Yield for exposed specimens vs. control specimens shall not exceed 20 percent after all specified exposure periods.

F. The average reduction of Elongation at Break for exposed specimens vs. control specimens shall not exceed 50 percent after all specified exposure periods.

4.10.2 Testing shall be performed in accordance with Appendix J.

4.11 Additional Tests

Additional tests may be required, at the discretion of certification agency, depending on design features and results of any foregoing tests.

5 OPERATIONS REQUIREMENTS

5.1 Demonstrated Quality Control Program

5.1.1 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.

5.1.2 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.

5.1.3 Documentation/Manual

There should be 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.

5.1.4 Records

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

5.1.5 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 required to 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.

5.2 Surveillance Audit

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

5.2.2 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.

5.3 Manufacturer's Responsibilities

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

5.4 Manufacturing and Production Tests

5.4.1 *Test Requirement No. 1 – Hydrostatic Test*

The manufacturer shall perform hydrostatic pressure testing on 100 percent of production pipe that bears the certification agency's mark of conformity in accordance with the specification used to produce the pipe. Lengths of pipe that fail testing shall be suitably marked as scrap and segregated from satisfactory material. Where the national or international standard used in the manufacturing of steel sprinkler pipe permits an alternate method of testing, such as eddy current inspection of the weld area, in lieu of hydrostatic pressure testing, acceptance of the alternate test method is at the discretion of the certification agency. The manufacturer shall have a controlled procedure on file for conducting this test, calibration records for the equipment used, a controlled set of calibration test samples, and disposition procedure of the rejected material.

5.4.2 *Test Requirement No. 1 – Flattening Test*

The manufacturer shall perform flattening tests as required by the specification that is used to produce the pipe. The manufacturer shall have a controlled procedure on file for conducting this test, recording the data and facilities for storing the data for recall as necessary.

5.4.3 *Other*

The manufacturer may conduct flaring (cone) tests; roll grooving tests, etc. at their option, as additional quality tests. These additional tests shall be described in the manufacturer's Quality Assurance Manual, and information recorded and stored as detailed in Section 5.5.2.

6 BIBLIOGRAPHY

ASTM A123/A123M – 12, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.*

ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

ASTM G1 – 03, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens*

AWWA C210-03, *AWWA Standard for Liquid-Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines*

ASTM D543-06, *Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents*

ASTM D638-10, *Standard Test Method for Tensile Properties of Plastics*

ASTM F442-13, *Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*

BS EN 228-1, 3rd Edition (2003), Pipe threads where pressure-tight joints are made on the threads – Part 1: Dimensions, tolerances, and designation

BS EN 10226-1:2004, *Pipe threads where pressure tight joints are made on the threads. Taper external threads and parallel internal threads. Dimensions, tolerances and designation*

BS EN 10226-2:2005, *Pipe threads where pressure tight joints are made on the threads. Taper external threads and taper internal threads. Dimensions, tolerances and designatio*n

BS EN 10226-3:2005, *Pipe threads where pressure-tight joints are made on the threads. Verification by means of limit gauges*

ISO 22088-3 (2006), *Plastics – Determination of Resistance to Environmental Stress Cracking (ESC)*

APPENDIX A:

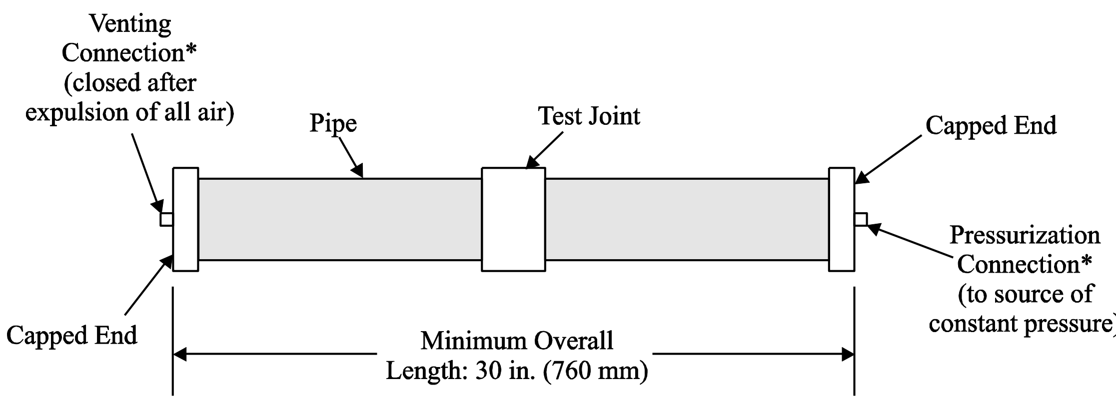
Appendix A is intentionally blank

APPENDIX B:

Appendix B is intentionally blank

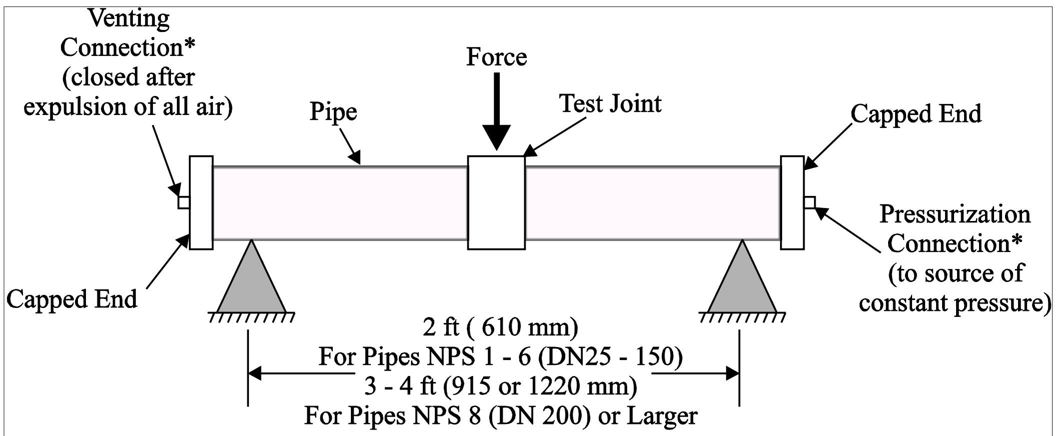
APPENDIX C: Figures

Figure C-1. Hydrostatic Test Sample



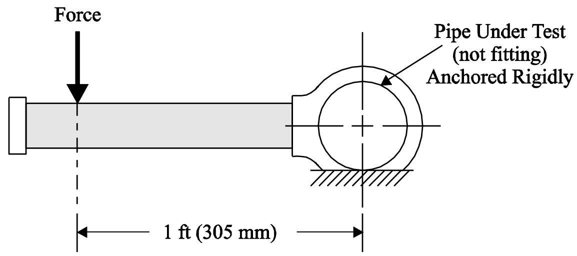
*End caps shall be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

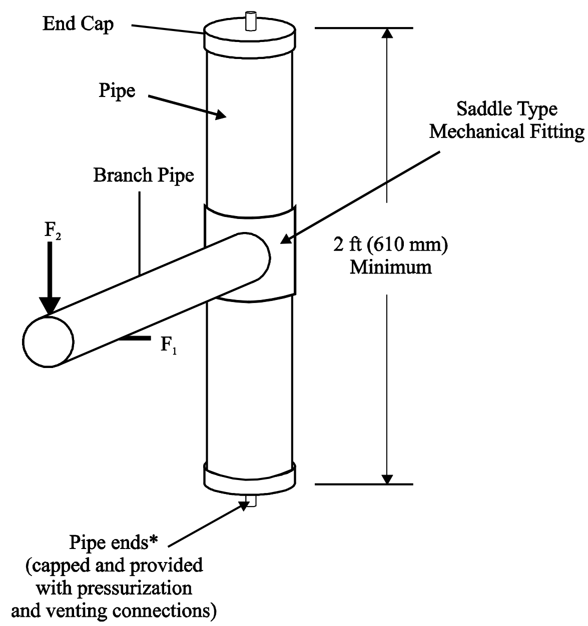
Figure C-2. Bending Moment Test



*End caps shall be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

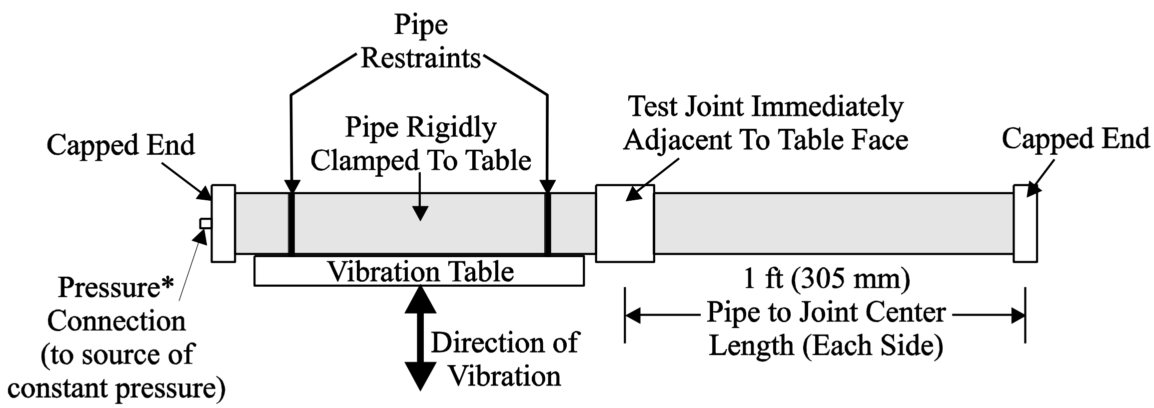
Figure C-3. Rotational Torque Tests





*End caps shall be drilled and tapped to 3/8 or 1/2 inch NPT
in order to make use of standard connectors.
Manufacturer to supply connectors if other than NPT.

Figure C-4. Vibration Test



*End Caps shall be drilled and tapped to 3/8 or ½ inch NPT in order to make use of standard connections. Manufacturer to supply connectors if other than NPT.

APPENDIX D: Bending Moment Calculations

Example: Calculate the bending moment for a length of 4 inch Schedule 40 steel sprinkler pipe.

Given:
Hanger spacing, L_{hs} = 15 ft (4.6 m) (maximum)
NPS 4 (DN 100) nominal pipe outside diameter, OD = 4.500 inches (115 mm)
Wall thickness (nominal), T = 0.237 inches (6mm)
Safety Factor, SF = 2
Density of Steel, ρ_p = 0.2836 lb/in^3 (7.85 g/cm^3)
Density of Water, ρ_w = 62.4 lb/ft^3 (1725 g/cm^3)

Where:

ID	Inside Diameter, in.	W_p	Weight of Steel per Foot of Pipe
A_p	Cross Sectional Area, in^2	V_p	Volume of Steel per Foot of Pipe
W_w	Weight of Water per Foot	L	Length
V_w	Volume of Water per Foot	M	Bending Moment
A_{wf}	Cross Sectional Area of Water Flow	L_{hs}	Length between Hangers
		SF	Safety Factor
W_{40}	Weight of Water Filled Schedule 40 Pipe per Foot	L_s	Length between Test Supports
		F_{40}	Force Required to Produce Equivalent Bending Moment

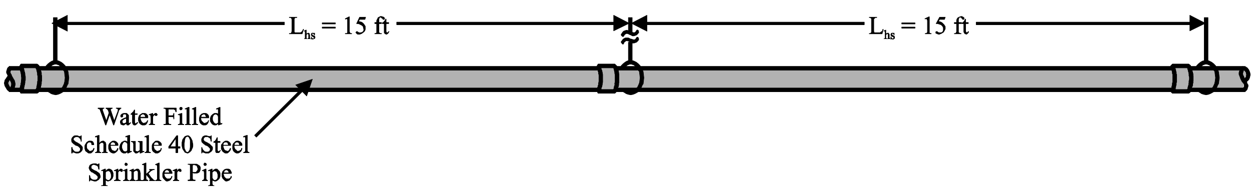


Figure D-1. Bending Moment Calculation

$$ID = OD - 2 \times T \quad \textbf{(Eq. 1)}$$

$$= 4.5\ in. - 2 \times (0.237\ in.) = 4.026\ in.$$

$$A_p = \frac{\pi\left(OD^2 - ID^2\right)}{4} \quad \textbf{(Eq. 2)}$$

$$= \frac{\pi\left[(4.5\ in.)^2 - (4.026\ in.)^2\right]}{4} = 3.174\ in.^2$$

$$V_p = A_p \times L \quad \textbf{(Eq. 3)}$$

$$= 3.174\ in.^2 \times \frac{12\ in.}{1\ ft} = 38.09\frac{in.^3}{ft}$$

APPENDIX D: Bending Moment Calculations
(Continued)

$$V_w = A_{wf} \times L = \left(\frac{\pi (ID)^2}{4} \right) \times L \qquad \textbf{\textit{(Eq. 4)}}$$

$$= \left(\frac{\pi (4.026\, in.)^2}{4} \right) \times 12 \frac{in.}{ft} = 152.76 \frac{in.^3}{ft}$$

$$W_p = V_p \times \rho_p \qquad \textbf{\textit{(Eq. 5)}}$$

$$= 38.09 \frac{in.^3}{ft} \times 0.2836 \frac{lb}{in.^3} = 10.79 \frac{lb}{ft}$$

$$W_w = V_w \times \rho_w \qquad \textbf{\textit{(Eq. 6)}}$$

$$= \left(152.76 \frac{in.^3}{ft} \right) \times \left(\frac{62.4 \frac{lb}{ft^3}}{1728 \frac{in.^3}{ft^3}} \right) = 5.52 \frac{lb}{ft}$$

$$W_{40} = W_p + W_w \qquad \textbf{\textit{(Eq. 7)}}$$

$$= 10.79 \frac{lb}{ft} + 5.52 \frac{lb}{ft} = 16.31 \frac{lb}{ft}$$

$$M = SF \times \left(\frac{W_{40} \times (2L_{hs})^2}{8} \right) \cdot ft \qquad \textbf{\textit{(Eq. 8)}}$$

$$= 2 \times \left(\frac{16.31 \frac{lb}{ft} \times (2 \times 15\, ft)^2}{8} \right) = 3669.75 lb \cdot ft \approx 3670 lb$$

APPENDIX D: Bending Moment Calculations (Continued)

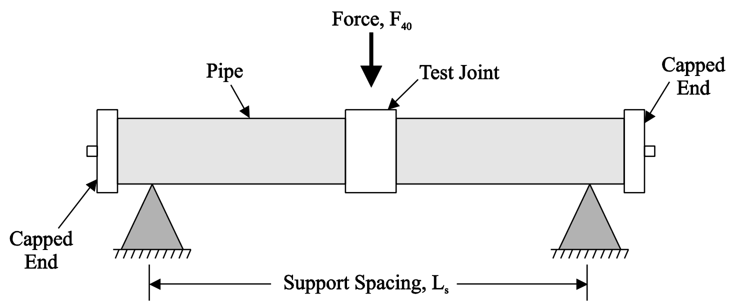


Figure D-2. Bending Moment Resistance Test

$$M = \frac{F_{40} \times L_s}{4} \rightarrow F_{40} = \frac{4 \times M}{L_s} \qquad \textbf{\textit{(Eq. 9)}}$$

$$F_{40} = \frac{4 \times (3670\ lb \cdot ft)}{4\ ft} = 3670\ lbs$$

if L_s = 4 then F_{40} = M
if L_s = 3 then F_{40}= 1.33 M
if L_s = 2 then F_{40}= 2M
Maximum moment = FL

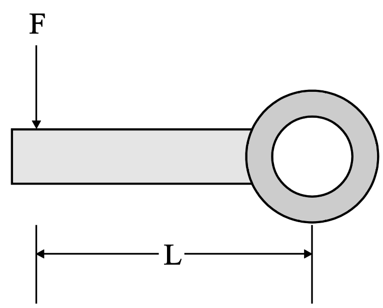


Figure D-3. Rotational Bending Moment Calculations

Maximum moment = the same as derived from grooved end couplings

Therefore, at a distance of L=1 ft, F=M/L

APPENDIX E: Bending Moments

Table E-1. ASME B36.10M, Schedule 40 Steel Pipe

Nominal Pipe Size		*Nominal Dimensions*				*Bending Moment*		*Load Required to Produce Minimum Bending Moments*					
		Outside Diameter		*Wall Thickness*				*2 Feet Between Supports*		*3 Feet Between Supports*		*4 Feet Between Supports*	
NPS	*(DN)*	*in*	*(mm)*	*in.*	*(mm)*	*lb-ft*	*(N-m)*	*lb*	*(N)*	*lb*	*(N)*	*lb*	*(N)*
1	**(25)**	1.315	(33.4)	0.133	(3.4)	295	(400)	590	(2625)	395	(1755)	295	(1310)
1-1/4	**(32)**	1.660	(42.2)	0.140	(3.6)	420	(570)	840	(3735)	560	(2490)	420	(1870)
1-1/2	**(40)**	1.900	(48.3)	0.145	(3.7)	810	(1100)	1620	(7205)	1080	4805)	810	(3605)
2	**(50)**	2.375	(60.3)	0.154	(3.9)	1150	(1560)	2300	(10 230)	1535	(6830)	1150	(5115)
2-1/2	**(65)**	2.875	(73.0)	0.203	(5.2)	1770	(2400)	3540	(15 745)	2360	(10 495)	1770	(7875)
3	**(80)**	3.500	(88.9)	0.216	(5.5)	2425	(3290)	4850	(21 575)	3235	(14 390)	2425	(10 785)
3-1/2	**(90)**	4.000	(101.6)	0.226	(5.7)	3015	(4090)	6030	(26 820)	4020	(17 880)	3015	(13 410)
4	**(100)**	4.500	(114.3)	0.237	(6.0)	3670	(4975)	7340	(32 650)	4890	(21 750)	3670	(16 325)
5	**(125)**	5.563	(141.3)	0.258	(6.6)	5240	(7105)	10 480	(46 615)	6985	(31 070)	5240	(23 310)
6	**(150)**	6.625	(168.3)	0.280	(7.1)	7090	(9615)	14 180	(63 075)	9450	(42 035)	7090	(31 535)
8	**(200)**	8.625	(219.1)	0.322	(8.2)	11 310	(15 335)	22 620	(100 615)	15 075	(67 055)	11 310	(50 305)
10	**(250)**	10.750	(273.1)	0.365	(9.3)	16 805	(22 790)	33 610	(149 495)	22 400	(99 635)	16 805	(74 750)
12	**(300)**	12.750	(323.9)	0.406	(10.3)	22 970	(31 145)	45 940	(204 340)	30 620	(136 200)	22 970	(102 170)

Notes:
1. The values for the Nominal Dimensions were referenced from ASME B36.10M, Copyrighted by The American Society of Mechanical Engineers.
2. The values in U. S. customary units are regarded as the requirements of this standard. The SI equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.

APPENDIX E: Bending Moments (Continued)

Table E-2. ASME B36.10M, Schedule 30 Steel Pipe

Nominal Pipe Size		***Nominal Dimensions***				***Bending Moment***		***Load Required to Produce Minimum Bending Moments***					
		Outside Diameter		***Wall Thickness***				***2 Feet Between Supports***		***3 Feet Between Supports***		***4 Feet Between Supports***	
NPS	***(DN)***	***in***	***(mm)***	***in.***	***(mm)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***lb***	***(N)***	***lb***	***(N)***
1	**(25)**	1.315	(33.4)	0.114	(2.9)	270	(365)	540	(2400)	360	(1600)	270	(1200)
1-1/4	**(32)**	1.660	(42.2)	0.117	(3.0)	380	(515)	760	(3380)	505	(2245)	380	(1690)
1-1/2	**(40)**	1.900	(48.3)	0.125	(3.2)	740	(1005)	1480	(6585)	985	(4380)	740	(3290)
2	**(50)**	2.375	(60.3)	0.125	(3.2)	1020	(1385)	2040	(9075)	1360	(6050)	1020	(4535)
2-1/2	**(65)**	2.875	(73.0)	0.188	(4.8)	1695	(2300)	3390	(15 080)	2260	(10 050)	1695	(7540)
3	**(80)**	3.500	(88.9)	0.188	(4.8)	2245	(3045)	4490	(19 970)	2995	(13 320)	2245	(9985)
3-1/2	**(90)**	4.000	(101.6)	0.188	(4.8)	2730	(3700)	5460	(24 285)	3640	(16 190)	2730	(12 145)
4	**(100)**	4.500	(114.3)	0.188	(4.8)	3250	(4405)	6500	(28 910)	4330	(19 260)	3250	(14 455)
5	**(125)**	5.563	(141.3)	0.188	(4.8)	4490	(6090)	8980	(39 945)	5985	(26 620)	4490	(19 970)
6	**(150)**	6.625	(168.3)	0.219	(5.6)	6305	(8550)	12 610	(56 090)	8405	(37 385)	6305	(20 045)
8	**(200)**	8.625	(219.1)	0.277	(7.0)	10 550	(14 305)	21 100	(93 855)	14 065	(62 560)	10 550	(46 925)
10	**(250)**	10.750	(273.1)	0.307	(7.8)	15 580	(21 125)	31 160	(138 600)	20 770	(92 385)	15 580	(69 300)
12	**(300)**	12.750	(323.9)	0.330	(8.4)	21 050	(28 545)	42 100	(187 260)	28 060	(124 810)	21 050	(93 630)

Notes:
1. The values for the Nominal Dimensions were referenced from ASME B36.10M, Copyrighted by The American Society of Mechanical Engineers.
2. The values in U. S. customary units are regarded as the requirements of this standard. The SI equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.
4. The values shown in this table are for reference only. The intent is to provide a guideline for pipes not shown on the tables in this Appendix. All certification tests shall be performed to the test load values shown in the ASME B36.10M, Schedule 40 table.

APPENDIX E: Bending Moments (Continued)

Table E-3. ASME B36.10M, Schedule 10 Steel Pipe

Nominal Pipe Size		Nominal Dimensions				Bending Moment		Load Required to Produce Minimum Bending Moments					
		Outside Diameter		Wall Thickness				2 Feet Between Supports		3 Feet Between Supports		4 Feet Between Supports	
NPS	(DN)	in	(mm)	in.	(mm)	lb-ft	(N-m)	lb	(N)	lb	(N)	lb	(N)
1	**(25)**	1.315	(33.4)	0.109	(2.8)	260	(355)	520	(2315)	345	(1535)	260	(1155)
1-1/4	**(32)**	1.660	(42.2)	0.109	(2.8)	360	(490)	720	(3205)	480	(2135)	360	(1600)
1-1/2	**(40)**	1.900	(48.3)	0.109	(2.8)	690	(935)	1380	(6140)	920	(4095)	690	(3070)
2	**(50)**	2.375	(60.3)	0.109	(2.8)	950	(1290)	1900	(8450)	1265	(5625)	950	(4225)
2-1/2	**(65)**	2.875	(73.0)	0.120	(3.0)	1325	(1795)	2650	(11 785)	1765	(7850)	1325	(5895)
3	**(80)**	3.500	(88.9)	0.120	(3.0)	1790	(2425)	3580	(15 925)	2385	(10 610)	1790	(7960)
3-1/2	**(90)**	4.000	(101.6)	0.120	(3.0)	2205	(2990)	4410	(19 615)	2940	(13 075)	2205	(9810)
4	**(100)**	4.500	(114.3)	0.120	(3.0)	2655	(3600)	5310	(23 620)	3540	(15 745)	2655	(11 810)
5	**(125)**	5.563	(141.3)	0.134	(3.4)	3895	(5280)	7790	(34 650)	5190	(23 085)	3895	(17 325)
6	**(150)**	6.625	(168.3)	0.134	(3.4)	5185	(7030)	10 370	(46 125)	6910	(30 735)	5185	(23 065)
8	**(200)**	8.625	(219.1)	0.188	(4.8)	9025	(12 240)	18 050	(80 285)	12 030	(53 510)	9025	(40 145)
10	**(250)**	10.750	(273.1)	0.188	(4.8)	13 015	(17 650)	26 030	(115 780)	17 350	(77 175)	13 015	(57 890)
12	**(300)**	12.750	(323.9)	0.188	(4.8)	17 405	(23 600)	34 810	(154 835)	23 200	(103 195)	17 405	(77 415)

Notes:

1. The values for the Nominal Dimensions were referenced from ASME B36.10M, Copyrighted by The American Society of Mechanical Engineers.
2. The values in U. S. customary units are regarded as the requirements of this standard. The SI equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.
4. The values shown in this table are for reference only. The intent is to provide a guideline for pipes not shown on the tables in this Appendix. All certification tests for test assemblies utilizing Schedule 10 pipe shall be performed to the test load values shown in the ASME B36.10M, Schedule 40 table.

APPENDIX E: Bending Moments (Continued)

Table E-4. ASME B36.10M, Schedule 5 Steel Pipe

Nominal Pipe Size		*Nominal Dimensions*				*Bending Moment*		*Load Required to Produce Minimum Bending Moments*					
		Outside Diameter		*Wall Thickness*				*2 Feet Between Supports*		*3 Feet Between Supports*		*4 Feet Between Supports*	
NPS	*(DN)*	*in*	*(mm)*	*in.*	*(mm)*	*lb-ft*	*(N-m)*	*lb*	*(N)*	*lb*	*(N)*	*lb*	*(N)*
1	**(25)**	1.315	(33.4)	0.065	(1.7)	295	(400)	590	(2625)	395	(1755)	295	(1310)
1-1/4	**(32)**	1.660	(42.2)	0.065	(1.7)	420	(570)	840	(3735)	560	(2490)	420	(1870)
1-1/2	**(40)**	1.900	(48.3)	0.065	(1.7)	520	(705)	1040	(4625)	695	(3090)	520	(2315)
2	**(50)**	2.375	(60.3)	0.065	(1.7)	735	(995)	1470	(6540)	980	(4360)	735	(3270)

Notes:
1. The values for the Nominal Dimensions were referenced from ASME B36.10M, Copyrighted by The American Society of Mechanical Engineers.
2. The values in U. S. customary units are regarded as the requirements of this standard. The SI equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.
4. The values shown in the Table above are derived using the weights of water filled Schedule 40 pipe per the dimensions of ASME B36.10M. However, the hanger spacings used in the calculations were revised to be 12 feet (3.6m) for all sizes.

APPENDIX E: Bending Moments (Continued)

Table E-5. EN 10255, Heavy Steel Pipe

Nominal Pipe Size		***Nominal Dimensions***				***Bending Moment***		***Load Required to Produce Minimum Bending Moments***					
		Outside Diameter		***Wall Thickness***				***2 Feet Between Supports***		***3 Feet Between Supports***		***4 Feet Between Supports***	
NPS	***(DN)***	***in***	***(mm)***	***in.***	***(mm)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***lb***	***(N)***	***lb***	***(N)***
1	**(25)**	1.331	(33.8)	0.157	(4.0)	335	(455)	670	(2980)	445	(1980)	335	(1490)
1-1/4	**(32)**	1.673	(42.5)	0.157	(4.0)	460	(625)	920	(4090)	615	(2735)	460	(2045)
1-1/2	**(40)**	1.906	(48.4)	0.157	(4.0)	855	(1160)	1710	(7605)	1140	(5070)	855	(3805)
2	**(50)**	2.374	(60.3)	0.177	(4.5)	1250	(1695)	2500	(11 120)	1665	(7405)	1250	(5560)
2-1/2	**(65)**	2.992	(76.0)	0.177	(4.5)	1735	(2355)	3470	(15 435)	2315	(10 295)	1735	(7715)
3	**(80)**	3.496	(88.8)	0.197	(5.0)	2300	(3120)	4600	(20 460)	3065	(13 635)	2300	(10 230)
4	**(100)**	4.492	(114.1)	0.213	(5.4)	3455	(4685)	6910	(30 735)	4605	()20 485	3455	(15 370)
5	**(125)**	5.500	(139.7)	0.213	(5.4)	4675	(6340)	9350	(41 590)	6230	(27 710)	4675	(20 795)
6	**(150)**	6.500	(165.1)	0.213	(5.4)	6040	(8190)	12 080	(53 730)	8050	(35 805)	6040	(26 865)

Notes:
1. The values for the Nominal Dimensions were referenced from British Standard BS EN 10255. Copyrighted by the British Standards Institution.
2. The values in SI units are regarded as the requirements of this standard. The U. S. customary equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.

APPENDIX E: Bending Moments (Continued)

Table E-6. EN 10255, Medium Steel Pipe

Nominal Pipe Size		***Nominal Dimensions***				***Bending Moment***		***Load Required to Produce Minimum Bending Moments***					
		Outside Diameter		***Wall Thickness***				***2 Feet Between Supports***		***3 Feet Between Supports***		***4 Feet Between Supports***	
NPS	***(DN)***	***in***	***(mm)***	***in.***	***(mm)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***lb***	***(N)***	***lb***	***(N)***
1	**(25)**	1.331	(33.8)	0.126	(3.2)	290	(395)	580	(2580)	385	(1710)	290	(1290)
1-1/4	**(32)**	1.673	(42.5)	0.126	(3.2)	400	(540)	800	(3560)	535	(2380)	400	(1780)
1-1/2	**(40)**	1.906	(48.4)	0.126	(3.2)	750	(1015)	1500	(6670)	1000	(4450)	750	(3335)
2	**(50)**	2.374	(60.3)	0.142	(3.6)	1095	(1485)	2190	(9740)	1460	(6495)	1095	(4870)
2-1/2	**(65)**	2.992	(76.0)	0.142	(3.6)	1535	(2080)	3070	(13 655)	2045	(9095)	1535	(6830)
3	**(80)**	3.496	(88.8)	0.157	(4.0)	2040	(2765)	4080	(18 150)	2720	(12 100)	2040	(9075)
4	**(100)**	4.492	(114.1)	0.177	(4.5)	3150	(4270)	6300	(20 020)	4200	(18 680)	3150	(14 010)
5	**(125)**	5.500	(139.7)	0.197	(5.0)	4510	(6115)	9020	(40 120)	6010	(26 730)	4510	(20 060)
6	**(150)**	6.500	(165.1)	0.197	(5.0)	5840	(7920)	11 680	(51 955)	7785	(34 630)	5840	(25 975)

Notes:
1. The values for the Nominal Dimensions were referenced from British Standard BS EN 10255. Copyrighted by the British Standards Institution.
2. The values in SI units are regarded as the requirements of this standard. The U. S. customary equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.
4. The values shown in this table are for reference only. The intent is to provide a guideline for pipes not shown on the tables in this Appendix. All certification tests for test assemblies utilizing Medium Steel pipe shall be performed to the test load values shown in the ASME B36.10M, Schedule 40 table.

APPENDIX E: Bending Moments (Continued)

Table E-7. JIS G3454 Schedule 40 Steel Pipe

Nominal Pipe Size		*Nominal Dimensions*				*Bending Moment*		*Load Required to Produce Minimum Bending Moments*					
		Outside Diameter		*Wall Thickness*				*2 Feet Between Supports*		*3 Feet Between Supports*		*4 Feet Between Supports*	
NPS	*(DN)*	*in*	*(mm)*	*in.*	*(mm)*	*lb-ft*	*(N-m)*	*lb*	*(N)*	*lb*	*(N)*	*lb*	*(N)*
1	**(25)**	1.339	(34.0)	0.134	(3.4)	305	(410)	610	(2715)	405	(1800)	305	(1355)
1-1/4	**(32)**	1.681	(42.7)	0.142	(3.6)	430	(585)	860	(3825)	575	(2560)	430	(1915)
1-1/2	**(40)**	1.913	(48.6)	0.146	(3.7)	820	(1110)	1640	(7295)	1095	(4870)	820	(3645)
2	**(50)**	2.382	(60.5)	0.154	(3.9)	1150	(1560)	2300	(10 230)	1535	(6830)	1150	(5115)
2-1/2	**(65)**	3.004	(76.3)	0.205	(5.2)	1890	(2565)	3780	(16 815)	2520	(11 210)	1890	(8405)
3	**(80)**	3.508	(89.1)	0.217	(5.5)	2435	(3300)	4870	(21 660)	3245	(14 435)	2435	(10 830)
3-1/2	**(90)**	4.000	(101.6)	0.224	(5.7)	3000	(4065)	6000	(26 690)	4000	(17 790)	3000	(13 345)
4	**(100)**	4.500	(114.3)	0.236	(6.0)	3660	(4960)	7320	(32 560)	4880	(21 705)	3660	(16 280)
5	**(125)**	5.504	(139.8)	0.260	(6.6)	5175	(7015)	10 350	(46 035)	6900	(30 690)	5175	(23 020)
6	**(150)**	6.504	(165.2)	0.280	(7.1)	6880	(9330)	13 760	(61 205)	9170	(40 790)	6880	(30 600)
8	**(200)**	8.516	(216.3)	0.323	(8.2)	11 090	(15 040)	22 180	(98 655)	14 785	(65 765)	11 090	(49 330)
10	**(250)**	10.528	(267.4)	0.366	(9.3)	16 275	(22 070)	32 550	(144 780)	21 695	(96 500)	16 275	(72 390)
12	**(300)**	12.539	(318.5)	0.406	(10.3)	22 340	(30 295)	44 680	(198 735)	29 780	(132 460)	22 340	(99 370)

Notes:
1. The values for the Nominal Dimensions were referenced from JIS G3454. Copyrighted by the Japanese Industrial Standards Committee.
2. The values in SI units are regarded as the requirements of this standard. The U. S. customary equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.

APPENDIX E: Bending Moments (Continued)

Table E-8. ASME B36.10M, Schedule 40 and Schedule 10 Steel Pipe Hybrid System Installation

Nominal Pipe Size		***Nominal Dimensions***						***Bending Moment***		***Load Required to Produce Minimum Bending Moments***					
		Outside Diameter		***Schedule 40 Wall Thickness***		***Schedule 10 Wall Thickness***				***2 Feet Between Supports***		***3 Feet Between Supports***		***4 Feet Between Supports***	
NPS	***(DN)***	***in.***	***(mm)***	***in.***	***(mm)***	***in.***	***(mm)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***lb***	***(N)***	***lb***	***(N)***
1	(25)	1.315	(33.4)	0.133	(3.38)	0.109	(2.77)	280	(380)	560	(2490)	375	(1670)	280	(1245)
1-1/4	(32)	1.660	(42.2)	0.14	(3.56)	0.109	(2.77)	395	(535)	790	(3515)	525	(2335)	395	(1755)
1-1/2	(40)	1.900	(48.3)	0.145	(3.68)	0.109	(2.77)	750	(1015)	1500	(6670)	1000	(4450)	750	(3335)
2	(50)	2.375	(60.3)	0.154	(3.91)	0.109	(2.77)	1055	(1430)	2110	(9385)	1405	(6250)	1055	(4695)
2-1/2	(65)	2.875	(73.0)	0.203	(5.16)	0.12	(3.05)	1560	(2115)	3120	(13 880)	2075	(9230)	1560	(6940)
3	(80)	3.500	(88.9)	0.216	(5.49)	0.12	(3.05)	2125	(2880)	4250	(18 905)	2830	(12 590)	2125	(9450)
3-1/2	(90)	4.000	(101.6)	0.226	(5.74)	0.12	(3.05)	2630	(3565)	5260	(23 400)	3500	(15 570)	2630	(11 700)
4	(100)	4.500	(114.3)	0.237	(6.02)	0.12	(3.05)	3190	(4325)	6380	(28 380)	4245	(18 885)	3190	(14 190)
5	(125)	5.563	(141.3)	0.258	(6.55)	0.134	(3.40)	4600	(6235)	9200	(40 925)	6120	(27 225)	4600	(20 460)
6	(150)	6.625	(168.3)	0.280	(7.11)	0.134	(3.40)	6185	(8385)	12370	(55 025)	8230	(36 610)	6185	(27 510)
8	(200)	8.625	(219.1)	0.322	(8.18)	0.188	(4.78)	10 205	(13835)	20410	(90 790)	13575	(60 385)	10205	(45 395)
10	(250)	10.750	(273.1)	0.365	(9.27)	0.188	(4.78)	14 980	(20310)	29960	(133 270)	19925	(88 630)	14980	(66 635)
12	(300)	12.750	(323.9)	0.406	(10.31)	0.188	(4.78)	20 295	(27515)	40590	(180 555)	26995	(120 080)	20295	(90 275)

Notes:

1. The values for the Nominal Dimensions were referenced from ASME B36.10M, Copyright 2004 by The American Society of Mechanical Engineers.
2. The values in U. S. customary units are regarded as the requirements of this standard. The SI equivalents are shown for reference.
3. The values shown for different support spacings are tabulated for clarity of the requirement. It is not necessary to perform bending moment resistance tests on each support spacing. These values were chosen based on commonly used test fixtures. For support spacings other than what is shown in the table above, please refer to the detailed calculation shown in Appendix D.
4. The values shown in the Table above are derived using the weights of water filled Schedule 40 and Schedule 10 pipes per the dimensions of ASME B36.10M-.

APPENDIX F: Rotational Bending Moments

Table F-1. ASME B36.10M Schedule 30 and Schedule 40

Nominal Pipe Size		ASME B36.10M Schedule 40				ASME B36.10M Schedule 30			
		Bending Moment		Load Required		Bending Moment		Load Required	
NPS	(DN)	lb-ft	(N-m)	Lb	(N)	lb-ft	(N-m)	lb	(N)
1	**(25)**	295	(400)	295	(1310)	270	(366)	270	(1200)
1-1/4	**(32)**	420	(570)	420	(1870)	380	(515)	380	(1690)
1-1/2	**(40)**	810	(1100)	810	(3605)	740	(1005)	740	(3290)
2	**(50)**	1150	(1560)	1150	(5115)	1020	(1385)	1020	(4535)
2-1/2	**(65)**	1770	(2400)	1770	(7875)	1695	(2300)	1695	(7540)
3	**(80)**	2425	(3290)	2425	(10 786)	2245	(3045)	2245	(9985)
3-1/2	**(90)**	3015	(4090)	3015	(13 410)	2730	(3700)	2730	(12 145)
4	**(100)**	3670	(4975)	3670	(16 325)	3250	(4405)	3250	(14 455)

Table F-2. ASME B36.10M Schedule 5 and Schedule 10

Nominal Pipe Size		ASME B36.10M Schedule 10				ASME B36.10M Schedule 5			
		Bending Moment		Load Required		Bending Moment		Load Required	
NPS	(DN)	lb-ft	(N-m)	lb	(N)	lb-ft	(N-m)	lb	(N)
1	**(25)**	260	(355)	260	(1155)	295	(400)	295	(1310)
1-1/4	**(32)**	360	(490)	360	(1600)	420	(570)	420	(1870)
1-1/2	**(40)**	690	(935)	690	(3070)	520	(705)	520	(2315)
2	**(50)**	950	(1290)	950	(4225)	735	(995)	735	(3270)
2-1/2	**(65)**	1325	(1795)	1325	(5895)	-	-	-	-
3	**(80)**	1790	(2425)	1790	(7960)	-	-	-	-
3-1/2	**(90)**	2205	(2990)	2205	(9810)	-	-	-	-
4	**(100)**	2655	(3600)	2655	(11 810)	-	-	-	-

APPENDIX F: Rotational Bending Moments (Continued)

Table F-3 BS EN 10255 Medium and Heavy and JIS G3454 Schedule 40

		BS EN 10255:2004 Medium				***BS EN 10255:2004 Heavy***				***JIS G3454-2007 Schedule 40***			
Nominal Pipe Size		***Bending Moment***		***Load Required***		***Bending Moment***		***Load Required***		***Bending Moment***		***Load Required***	
NPS	***(DN)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***lb-ft***	***(N-m)***	***lb***	***(N)***	***Lb-ft***	***(N-m)***	***lb***	***(N)***
1	**(25)**	290	(395)	290	(1290)	335	(455)	335	(1490)	305	(410)	305	(1355)
1-1/4	**(32)**	400	(540)	400	(1780)	460	(625)	460	(2045)	430	(585)	430	(1915)
1-1/2	**(40)**	750	(1015)	750	(3335)	855	(1160)	855	(3805)	820	(1110)	820	(3645)
2	**(50)**	1095	(1485)	1095	(4870)	1250	(1695)	1250	(5560)	1150	(1560)	1150	(5115)
2-1/2	**(65)**	1535	2080	1535	(6830)	1735	(2355)	1735	(7715)	1890	(2565)	1890	(8405)
3	**(80)**	2040	(2765)	2040	(9075)	2300	(3120)	2300	(10 230)	2435	(3300)	2435	(10 830)
3-1/2	**(90)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	3000	(4065)	3000	(13 345)
4	**(100)**	3150	(4270)	3150	(14 010)	3455	(4685)	3455	(15 370)	3660	(4960)	3660	(16 280)

Notes:
1. The above tables are based on the nominal pipe size of the outlet piping.
2. The above tables reflect the required test loading based on the load being applied 1 foot (0.30 m) from the run pipe axis.
3. The test assembly shall be pressurized to the lower rated working pressure of either the pipe or fitting.
4. For test assemblies with threaded outlets, the outlet pipe shall be Schedule 40 steel sprinkler pipe or equivalent.
5. For test assemblies with grooved outlets, the Outlet piping shall be the pipe under consideration for certification, if applicable, otherwise Schedule 10 will utilized.
6. The Schedules 10 and 30 rotational bending moment values are shown for reference only. certification testing for these Schedules will be performed using the Schedule 40 values.

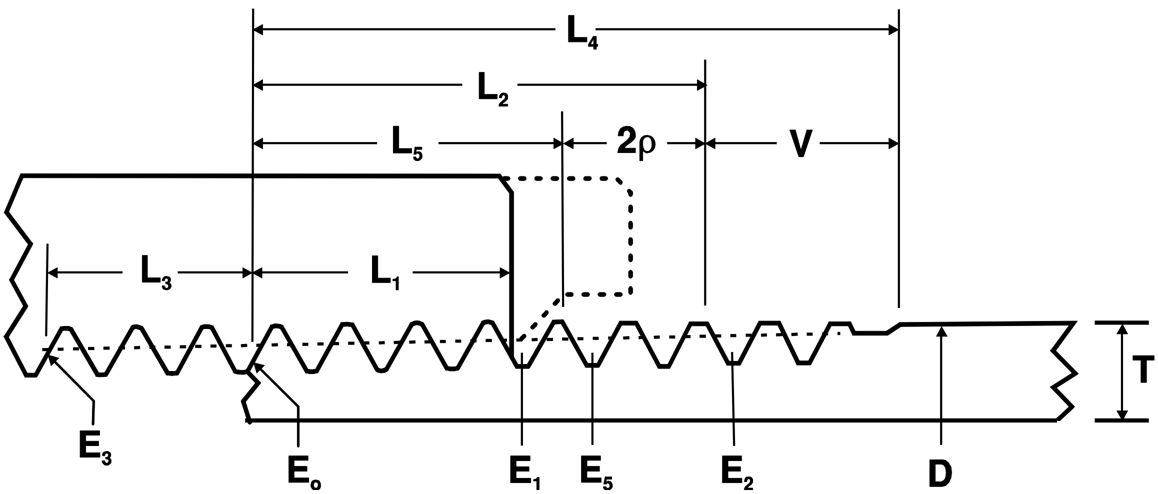
APPENDIX G: Remaining Pipe Wall Calculations

Example: Calculate the minimum resultant wall in a NPS 2 (DN 50) Schedule 40 steel sprinkler pipe after threading.

Given: NPS 2 (DN 50) nominal pipe outside diameter, OD = 2.375 in (60 mm) ± 1 percent
NPS 2 (DN 50) pipe wall thickness (nominal), T = 0.154 in (4 mm) ± 12.5 percent
Threading in accordance with ANSI/ASME B1.20.1 - NPT

Where:

ID -	Inside Diameter, in.	W_p -	Weight of Steel per Foot of Pipe
A_p -	Cross Sectional Area, in^2	V_p -	Volume of Steel per Foot of Pipe
W_w -	Weight of Water per Foot of Pipe	L -	Length



Establish the pitch diameter at the pipe end (E_0) for NPS 2 (DN 50) Schedule 40 pipe:

$$E_0 = D - (0.05D + 1.1) * p \quad \textit{(Eq. 1)}$$

Where: E_0 - Pitch diameter at end of pipe (External Thread), in
D - Outside diameter of pipe, Nominal, in
p - Thread pitch = 1/number of threads per inch

$$E_0 = 2.375 - [0.05 * (2.375) + 1.1] * \left(\frac{1}{11.5}\right) \quad \textit{(Eq.2)}$$

E_0=2.269 in

Length of wrench make-up = L_3= 3 threads = 0.2609 in ≈ 0.261 in

APPENDIX G: Remaining Pipe Wall Calculations (Continued)

L_1	=	is the normal length of engagement between internal and external taper threads when screwed together hand-tight.
T	=	Pipe wall thickness, Nominal
T_{min}	=	T - Tolerance on wall thickness
OD	=	Outside diameter of the pipe, nominal
OD_{max}	=	OD + Tolerance on pipe OD
ID_{max}	=	$OD_{max} - 2T_{min}$

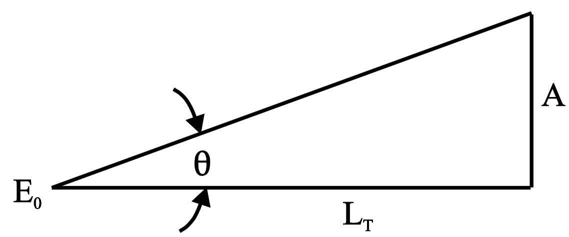
= 2.375 + 0 0238 - 2 x (0.154 - 0.019)
= 2.129 in (55 mm)

Next calculate the thread pitch diameter at the first unsupported thread.
The first unsupported thread is found at a distance of:

$L_T = L_1 + L_3$. *(Eq. 3)*

$L_T = L_1 + L_3 = 0.436 + 0.261 = 0.697$ in

The pitch diameter at L_T is calculated as:



$A = L_T$*tanØ *(Eq. 4)*

Where

Ø = thread taper angle = 1°47’ = 1°+47/60 = 1.7833°
A = 0.697 * tan 1.783°
A = 0.0217 inch per side

Therefore the pitch diameter E_3 at L_T is: $E_3 = E_0 + 2A$ *(Eq. 5)*
E_3 = 2.269+2*(0.0217) = 2.312 in

Accounting for the thread height (considered the maximum height for truncated threads):
H = 0.8 * p = 0.8*(1/11.5) = 0.0696 in *(Eq. 6)*

APPENDIX G: Remaining Pipe Wall Calculations (Continued)

Resultant wall thickness, Rw, is:

$$R_w = \frac{E_3 - 2\left(\frac{H}{2}\right) - ID_{\max}}{2} \qquad \textbf{\textit{(Eq. 7)}}$$

$$R_w = \frac{2.312 - 2\left(\frac{0.0696 in.}{2}\right) - 2.129}{2}$$

Rw = 0.0567 ≈ 0.057 in

APPENDIX H: Sample Listing

Standard Steel Pipe for Automatic Fire Sprinkler Systems Listing

The example has been created for Schedule 40, but shall apply for Schedule 40, Schedule 10, Thinwall, Lightwall, and Schedule 5 steel sprinkler pipe.

Manufacturer	***Product Description***	***Nominal Pipe Size, NPS***	***Rated Working Pressure, psi, (kPa)***	***Remarks***
A Company	Schedule 40 Steel Pipe	2, 3, 4	300 (2070)	a, b, c, d
B Company	Schedule 40 Steel Pipe	¾, 1, 1¼, 1½, 2	175 (1205)	a, b, c, d, e, f
C Company	Schedule 40 Steel Pipe	1, 1¼, 1½, 2, 2½, 3, 4, 6	300 (2070)	a, b, c, d

Remarks:

a. Certified for Dry Systems when supplied hot dipped galvanized by factory.
b. For use with certified pipe couplings on rolled or cut grooves.
c. For use with certified pipe fittings when threaded.
d. For use in welded systems when supplied with standard bevel on ends
e. For use with certified plain end fittings at 175 psi (1205 kPa).
f. Certification of NPS 1/2 and 3/4 (DN 15 and 20) pipe is permitted for use as valve trim, gauge connections, and for other peripheral service.

APPENDIX I: 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 internally coated steel pipe is in hybrid sprinkler systems (i.e. internally coated steel pipe connected to plastic pipe), evaluation of internally coated steel pipe under this standard shall include chemical compatibility testing with representative samples of all certified plastic pipe and fittings in accordance with Appendix I.

I.1 Requirement:

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 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 and edges 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 consideration will be given to the shape of the test samples and will be determined by the certification agency at the time of project initiation.

I.2 Test/Verification:

Deionized (DI) water shall be used to extract antibacterial or antimicrobial coatings from the inside surfaces of steel sprinkler pipe samples submitted for certification 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 foot (1.52 m) long NPS 3 (DN 80) NPS piece of coated pipe.
- Cover the Teflon® PTFE film with a 3 in. (76 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 NPS 1 (DN 25) certified chlorinated polyvinyl chloride (CPVC) or other certified plastic pipe being considered for certification in hybrid fire sprinkler systems with steel pipes with antimicrobial or antibacterial coatings.

- The dimensions of Type V tensile specimens are shown in Figure I-2-1 for a 1 inch NPS specimen of 13.5 SDR CPVC 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 NPS 1 (DN 25) 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 NPS 1 (DN 25) CPVC or other plastic pipe as shown in Figure I-2-2 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 per ASTM F442) shall be tested for each condition.

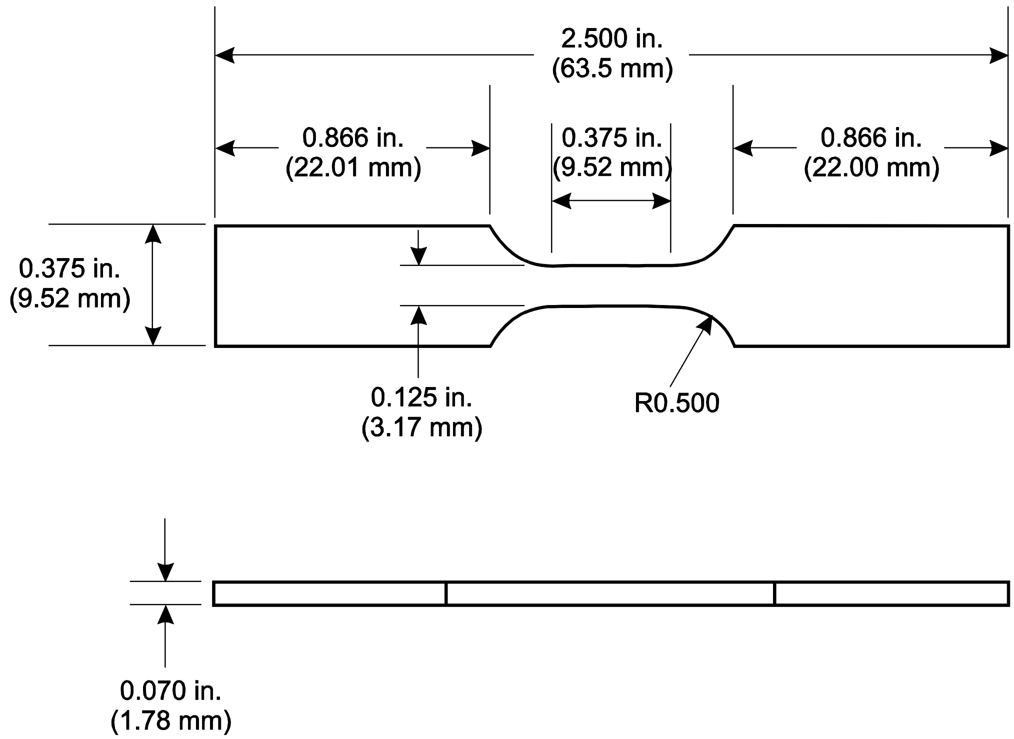


Figure I-2-1 - Schematic drawing for dimensions of Type V tensile specimens in accordance with ASTM D638 of NPS 1 (DN 25) CPVC in accordance with ASTM F442 (units in inches).

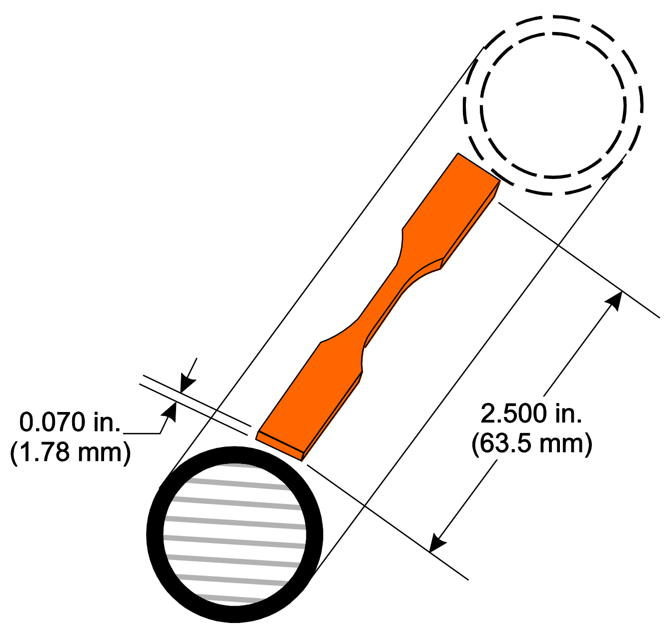


Figure I-2-2 - Schematic drawing for the machining direction of the Type V tensile specimen in accordance with ASTM D638 of NPS 1 (DN 25) CPVC pipe in accordance with ASTM F442 (units in inches).

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 NPS 1 (DN 25) CPVC pipe per ASTM F442). Ensure that at least 0.7 inch (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 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: Upon removal from the test fixture, prior to tensile testing, 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.

APPENDIX J: Corrosion Evaluation Test Protocol

Evaluation of Corrosion Properties and Chemical Compatibility of Non-Galvanized Internally Coated Steel Fire Sprinkler Pipes

If the steel pipe is available with an internal coating that is intended to be installed in both wet and dry pipe sprinkler systems (including hybrid sprinkler systems), evaluation of internally coated steel pipe under this standard shall include corrosion evaluation testing with representative samples in accordance with Appendix J.

J.1 Requirement:

The internal coating, when applied to the steel pipe under evaluation, shall meet all of the following requirements:

A. The corrosion rate (CRw) of the internally coated pipe samples after 90 day's exposure time shall be less than the corrosion rate of galvanized pipe after 90 day's exposure time;

B. The adhesion rate shall be greater than 800 psi (5.5 MPa) plus the standard deviation of the measurements taken;

C. The coating thickness shall not be less than a standard deviation of its nominal thickness;

D. The tensile surface and edges of the exposed specimens shall not exhibit any visually observable cracks or crazes after all specified exposure periods;

E. The average reduction of Tensile Strength at Yield for exposed specimens vs. control specimens shall not exceed 20 percent after all specified exposure periods;

F. The average reduction of Elongation at Break for exposed specimens vs. control specimens shall not exceed 50 percent after all specified exposure periods.

J.2 Test/Verification:

J.2.1 Measurement of Coating Thickness

- Prepare four (4) 3 inch NPS (DN80) pipe sections, each approximately five (5) inches in length, with the coating under evaluation on both the inside and outside diameter surfaces. Each pipe section shall be longitudinally cut into two halves.
- Calibrate the coating thickness gauge using the gauge manufacturer's Certified Thickness Standards.
- Zero the coating thickness gauge using the gauge manufacturer's uncoated standard.
- Using the properly calibrated coating thickness gauge, measure the coating thickness on six (6) locations on both the inside and outside diameter surfaces of each section of pipe.
- Average coating thickness with standard deviation shall be calculated for each of the four (4) test samples.

J.2.2 Measurement of Coating Adhesion Strength

- Prepare a 3 inch NPS (DN80) pipe section, approximately 24 inch (610 mm) length, with the coating under evaluation on both the inside and outside diameter surfaces. The pipe section shall be longitudinally cut into two halves.

- Rough five (5) equally spaced surfaces on both the inside and outside diameter surfaces using 120 grit silicon carbide paper.
- Using the same 120 grit silicon carbide paper, rough the flat surfaces of the test dollies which will be used during the test.
- Clean both pipe sections and the flat surfaces on the test dollies using isopropyl alcohol and allow to fully dry before handling.
- Using a high strength epoxy adhesive, attach the roughened dollies to the ten (10) prepared areas on the inside and outside diameter surfaces of each test pipe and apply a steady pressure to the dollies for 2 minutes.
- Allow the adhesive to fully cure before attaching the adhesion testing apparatus to each of the steel dollies.
- Using the adhesion testing apparatus, apply an increasing hydraulic pulling force to each of the steel dollies until each steel dolly detaches from the test pipe.
- Average adhesion strength with standard deviation shall be calculated for the sample size of (twenty) 20 test measurements.

J.2.3 Salt Fog Cyclic Corrosion Chamber Testing

- Prepare sixty (60) pipe coupons of 1 inch (25.4 mm) (transverse direction) x 2 inch (50.8 mm) (longitudinal direction) with 1/16 inch (0.0625 inch) (1.6 mm) diameter holes located between 1/8 inch (0.125 inch) (3.2 mm) to 3/16 inch (0.1875 inch) (4.8 mm) from each coupon corner; fifteen (15) pipe coupons taken from each of the following pipe types; stainless steel; galvanized steel; carbon steel; and carbon steel with the coating under evaluation on all surfaces (including edges).
- Prepare sixty (60) 3 inch NPS (DN80) pipe sections, fifteen (15) from stainless steel pipe; fifteen (15) from galvanized carbon steel pipe; fifteen (15) from carbon steel pipe; and fifteen (15) from carbon steel pipe with the coating under evaluation on all surfaces (including edges), each approximately five (5) inches (127 mm) in length.
- Precisely weigh each coupon and document each measurement, out to seven significant figures
- Thread nylon wire longitudinally through the drilled holes of each pipe coupon such that, on the coupon's undersides, it runs most of their lengths.
- Thread nylon wire through each individual 5 inch (127 mm) pipe section.
- Attach the pipe sections and pipe coupons to plastic hooks, and hang from fiber-reinforced plastic rods that run transversely inside of the test chamber.
- Once all test specimens are placed in the test chamber, power on the salt fog cycling corrosion chamber and allow the chamber to operate continuously during the length of the test program.
- After 14, 30 and 90 days of exposure, remove five (5) pipe sections of each type from the test chamber and allow to fully dry.
- Photograph each pipe section to document the visual appearance after removal from the test chamber.
- After 14, 30 and 90 days of exposure, remove five (5) pipe coupons of each type from the test chamber. Rinse each pipe coupon with tap water and allow to fully dry. Then, using a wire brush, brush off all corrosion products from each surface of the coupons.
- Precisely weigh each pipe coupon and record each measurement, out to seven significant figures.
- Calculate the corrosion rate (CRw), in mils per year, by using the average corrosion rate equation found in ASTM G1 shown below.

$$CRw = (K \times W) / (A \times T \times D)$$

Where:
K = a constant ($K = 3.45 \times 10^6$)
T = time of exposure in hours
A = area in cm^2
W = mass loss in grams, and
D = density in g/cm^3

J.2.4 Chemical Compatibility Testing

- Testing shall be performed in accordance with Appendix I

APPENDIX K: Tolerances

Unless otherwise stated, the following tolerances shall apply:

Angle	± 2°
Frequency (Hz)	± 5 percent of value
Length	± 2 percent of value
Volume	± 5 percent of value
Volume Per Unit Area	± 5 percent of value
Pressure	± 5 psi (35 kPa)
Temperature	± 4°F (2°C)
Time	+ 5/–0 seconds
	+0.1/–0 minutes

Unless stated otherwise, all tests shall be carried out at a room (ambient) temperature of 68 ± 9°F (20 ± 5°C).