Approval Standard for Pipe Couplings and Fittings for Aboveground Fire Protection Systems

Class Number 1920

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Foreword

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

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

For examining equipment, materials and services, Approval Standards:

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

b) must be readily identifiable.

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

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

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1. INTRODUCTION

1.1 Purpose

1.1.1 This standard states Approval criteria for threaded, grooved, welded, flanged, specialized and plain end pipe joining methods and the associated fittings for use in aboveground automatic fire protection systems.

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

1.2 Scope

1.2.1 This standard encompasses the design and performance requirements for grooved end couplings and other pipe fittings, outlined below, for use with steel pipe in either wet or dry pipe sprinkler systems, or both, but in all cases for aboveground fire protection systems. Typical applications are in sprinkler risers, in feed mains passing through walls from one building area to another, branch lines, or in locations subject to earthquakes, in the discharge line from aboveground pump suction tanks, in new connections to existing feed mains, and in air or water fire service lines subject to excess vibration or difficult alignment.

1.2.2 This standard encompasses the design and performance requirements for sizes: 1/2, 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, and 4 inch NPS threaded fittings. The sizes indicated are for fittings with equal size outlets. For reducing fittings, the minimum reduced outlet size covered in this standard is 1/4 inch NPS.

1.2.3 This standard encompasses the design and performance requirements for sizes: 3/4, 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 5, 6, 8, 10, and 12 inch NPS grooved end couplings, reducing couplings, grooved split flanges, mechanical tees, mechanical crosses, and standard grooved end pipe fittings.

1.2.4 This standard encompasses the design and performance requirements for sizes: 1, 1-1/4, 1-1/2, 2, and 2-1/2 inch NPS plain end couplings and fittings.

1.2.5 This standard encompasses the design and performance requirements for run sizes: 1, 1-1/4, 1-1/2, 2, 2-1/2, 3, 3-1/2, 4, 5, 6, and 8 inch NPS welded branch outlet fittings. The maximum outlet size for these fittings is limited to one pipe size smaller than the run pipe to which they are welded. Equal size outlets are not permitted.

1.2.6 This standard encompasses the design and performance requirements for sizes: 2, 2-1/2, 3, 3-1/2, 4, 5, 6, 8, 10, and 12 inch NPS flanged pipe fittings, and flange adapters.

1.2.7 This standard encompasses the design and performance requirements for sizes: 3/4, 1, 1-1/4, 1-1/2, and 2 inch NPS specialized pipe couplings and fittings.

1.2.8 Approval of products made in metric sizes is also incorporated into this Approval Standard. In the event that the test criteria for a metric size is not called out specifically, the nearest larger equivalent inch size value shall be used.

1.2.9 Due to the international availability of grooved couplings and other pipe fittings, the following table has been provided as a reference between nominal pipe sizes manufactured to ASME B36.10M-2000 dimensions and those of other standards.

Nominal Pipe Size		*Nominal Outside Diameter*	
NPS	***DN***	***Inch***	***mm***
1/2	15	0.840	21.7
3/4	20	1.050	27.2
1	25	1.315	33.4
1-1/4	32	1.660	42.7
1-1/2	40	1.900	48.3
2	50	2.375	60.3
2	65	2.875	73.1
2-1/2	-	2.995	76.1
3	80	3.500	88.9
3-1/2	90	4.000	101.6
4-1/4	-	4.250	108
4	100	4.500	114
5	125	5.000	127
5-1/4	-	5.250	133
5-1/2	-	5.500	139.7
5	125	5.625	141.3
6-1/4	-	6.250	159
6-1/2	-	6.500	165.1
6	150	6.625	168.3
8 (JIS)	-	-	216.3
8	200	8.625	219.1
10 (JIS)	-	-	267.4
10	250	10.750	273
12 (JIS)	300	-	318.5
12	300	12.750	323.9

1.2.10 Other types and sizes of gasketed pipe couplings and other pipe fittings may be FM Approved if they meet the requirements and intent of this standard. Gasketed pipe couplings and other pipe fittings of unusual design may be subjected to special tests to determine their suitability.

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 Approval Standards are intended to verify that the product described will meet stated conditions of performance, safety, and quality useful to the ends of property conservation. The requirements of this standard reflect tests and practices used to examine characteristics of pipe couplings and fittings for the purpose of obtaining Approval. Gasketed pipe couplings and other pipe fittings having characteristics not anticipated by this standard may be FM Approved if performance equal, or superior, to that required by this standard is demonstrated, or if the intent of the standard is met. Alternatively, pipe couplings and fittings which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist or if the intent of this standard is not met.

1.4 Basis for Approval

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

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

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

1.4.2 An initial facilities and procedures audit shall be conducted to evaluate the manufacturer's ability to consistently produce the product that was examined and tested as part of the Approval project. The audit shall review the facility and in-place quality control procedures used in the manufacturing of the product. Typically, areas of review are incoming inspection, work in progress, production testing, final quality control, marking, calibration of equipment, shipping procedures, and document and drawing control. These audits are repeated periodically as part of the FM Approvals product follow-up program. (Refer to Section 5.2, Facility and Procedures Audit.)

1.5 Basis for Continued Approval

1.5.1 Continued Approval is based upon:

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

1.5.2 Also, as a condition of retaining Approval, manufacturers may not change an FM Approved product or service without prior authorization by FM Approvals. (Refer to section 5.1.3 for further details regarding changes.)

1.6 Effective Date

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

The effective date of this standard is **March 31, 2009** for compliance with all requirements.

1.7 System of Units

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S. customary units is in accordance with Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-2002, *American National Standard for Use of the International System of Units (SI): The Modern Metric System.*

1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard:

ANSI B16.1 - 1998, *Cast Iron Pipe Flanges and Flanged Fittings*
ANSI B16.3 - 1998, *Malleable Iron Threaded Fittings*
ANSI B16.4 - 1998, *Gray Iron Threaded Fittings*
ANSI B16.11 - 2005, *Forged Fittings, Socket-Welded and Threaded*
ANSI/American Society of Mechanical Engineers (ASME) B1.20.1 - 1983, *Pipe Threads, General Purpose* (R2001),
ANSI/American Water Works Association (AWWA) C606-2004, *Grooved and Shouldered Joints*
ASTM A53/A53M - 2005, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*
ASTM A135/A135M - 2006, *Standard Specification for Electric-Resistance-Welded Steel Pipe*
ASTM A795/A795M - 2004, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*
Deutsches Institut für Normung e.V. (DIN) EN 10220 (2003-03), *Seamless and Welded Steel Tubes - Dimensions and Masses per Unit Length*
EN 10226-1 - 2004, *Pipe Threads Where Pressure Tight Joints Are Made on the Threads - Part 1: Taper External Threads and Parallel Internal Threads - Dimensions, Tolerances and Designation*
EN 10226-2 - 2005, *Pipe Threads Where Pressure-Tight Joints Are Made on the Threads - Part 2: Taper External Threads and Taper Internal Threads - Dimensions, Tolerances and Designation*
EN 10226-3 - 2005, *Pipe Threads Where Pressure-Tight Joints Are Made on the Threads - Part 3: Verification By Means Of Limit Gauges*
EN 10242 - 2003, *Threaded Pipe Fittings in Malleable Cast Iron*
EN 10255 - 2004, *Non-Alloy Steel Tubes Suitable For Welding and Threading - Technical Delivery Conditions*
FM Global Property Loss Prevention Data Sheets
IEEE/ASTM SI 10 - 2002, *Standard for Use of the International System of Units (SI): The Modern Metric System*
International Standard (ISO) 65 - 1981, *Carbon Steel Tube Suitable for Screwing in Accordance with ISO 7/1*
ISO 7/1 - 2000, *Pipe Threads: Designation, Dimensions/Tolerances*
ISO 4200 - 1991, *Plain End Steel Tubes, Welded and Seamless - General Tables of Dimensions and Masses per Unit Length*
ISO 17025 - *General Requirements for the Competence of Testing and Calibration Laboratories*
Japanese Industrial Standard (JIS) G3454 - 2005, *Carbon Steel Pipes for Pressure Service*
Malhotra, P. K., Senseny, P. E., Braga, A. C., and Allard, R. L. - 2003, *"Testing Sprinkler Pipe Seismic Brace Components",* Earthquake Spectra 19(1), pp 87-109.

1.9 Definitions

For purposes of this standard, the following terms apply:

Accepted

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

Blind Flange

A blind flange is a fitting that is used to block off fluid flow in flanged piping systems. This fitting is the equivalent of a plug or cap in threaded systems, or an end cap in grooved piping systems.

Concentric Reducer

A concentric reducer is a fitting that is used to make a transition from one pipe size to another along a common pipe axis. These fittings are available in any of the end connection types discussed in this Approval Standard. There is also a transition style of concentric reducer that can change end connection styles as well as pipe sizes within one fitting.

Coupling

A coupling is a fitting that is used to join two or more components together. For the purposes of this Approval Standard, the term "coupling" when used by itself, will refer to the threaded end type with equal connections. Other types of couplings will be identified by their proper names, such as grooved or gasketed couplings, plain end couplings, reducing couplings, etc.

Cross

A cross is a cast or fabricated fitting that is characterized by four coplanar inlets / outlets equally spaced around a common center. Cross fittings are available as equal fittings, or in reducing configurations. These fittings are typically supplied with all ends having the same type of end connection. The common end connections for cross fittings are: cut or roll grooved, threaded, or flanged.

Cut Groove

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

Eccentric Reducer

An eccentric reducer is a fitting that is used to make a transition from one pipe size to another that are not along the same pipe axis.

Elbow

A cast or fabricated fitting characterized by changing the direction of flow. This fitting is also commonly referred to as a "Bend". The typical angular changes are: 11-1/4, 22-1/2, 45, and 90 degrees. The common end connections for elbows are: threaded, cut groove, roll groove, flanged, or plain end.

Elbow, Base

A cast elbow with an integral support base extending out from the outer surface of the elbow to the floor. The base elbow is typically supplied with flanged end connections.

Elbow, Drain

A drain elbow is similar to the standard elbow but has an auxiliary port (typically threaded) to allow for the removal of water or air during maintenance. The drain elbow is commonly used at either the lowest or highest point in the piping system for this reason.

Elbow, Reducing

A reducing elbow is similar to the standard elbow, except the end connections are of the same type but are of different nominal pipe sizes.

Elbow, Street

A street elbow is similar to a standard elbow with the exception that the end connections are of different types. For example, a 1 inch NPS street elbow may have a female threaded inlet and male threaded outlet. These fittings are also available in reducing styles. The most common end connection for street elbows is threaded ends.

End Caps

An end cap is used to close off the end of a pipeline. End caps are available with grooved or threaded end connections.

End Connections

The term "End Connections" refers to the method of connecting components of a pipe system. Typical end connections in a fire protection service are cut groove, rolled groove, threaded, plain end, and welded end.

Fitting

The term "fitting" refers to a piping related product that is manufactured to standardized dimensions. These dimensions may exist in Industry Standards or be based on those of manufacturers that have been accepted by the market as the "norm".

Flange Adapters

A flange adapter is a fitting that makes the transition from one style of end connection to flange type connection as a single component. This is different from grooved split flanges as they are made of multiple components. Common types of flange adapters are grooved end by flange, and welding end by flange.

Flanged Fittings

The term flanged fittings has been taken to refer to any style of pipe fitting covered in the scope of this Approval Standard with integral flanged end connections.

FM Approvals Certification Marks

The FM Approvals Certification Marks are detailed in Appendix B. Their use is mandatory on all units of FM Approved products. These registered marks cannot be used except as authorized by FM Approvals via the granting of Approval to a specific product.

FM Approved

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

Grooved Coupling, Flexible

A grooved coupling is an assembly that is used to join two similar sized grooved ends together. The flexible grooved coupling is characterized by its ability to allow for angular, or rotational differences between the components being joined after assembly. These products may provide greater system reliability in situations involving excessive vibration, difficult alignment, or seismic activity. They may also provide greater system flexibility than historic use of rigid systems of flanged pipe and fittings.

Grooved Coupling, Reducing

A reducing grooved coupling is an assembly that is used to join two different sized grooved ends together. Telescoping of the smaller pipe into the larger is prevented by various means, such as a steel internal washer. Reducing grooved end couplings are available in flexible and rigid styles.

Grooved Coupling, Rigid

A rigid grooved coupling is an assembly that is used to join two similar sized grooved ends together. The rigid grooved coupling is characterized by its prevention of rotation of the joined ends, and reduced tolerance for angular variations after assembly.

Grooved Split Flange

A grooved split flange is an assembly that is used to make the transition from a grooved end to a flanged connection. Unlike the flange adapter which needs to be joined to the mating grooved end by means of a grooved coupling, the split flange acts as a grooved coupling and flange adapter. Sealing is achieved by the use of the gasket provided with the grooved split flange.

Lateral

A lateral is similar in configuration to a tee, with the exception of the branch outlet being at an angle to the run piping. Laterals are available with threaded, grooved, or flanged end connections.

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, roll grooved, 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.

Long Radius Elbows or Tees

A long radius tee or elbow is characterized as having a larger bend radius than a standard elbow or tees.

Mechanical Cross

A mechanical cross is created when two mechanical tees are used to cover through holes in a run pipe. The holes may or may not be of the same size. In this case, only the “saddles” of the mechanical tees, gaskets, and bolting are used.

Mechanical Tee

A mechanical tee is a fitting that provides a connection to a pipe line in place of a tee. The pipe is pre-drilled per the manufacturer’s instructed hole size, and the “saddle” is placed over the hole so that the mechanical tee gasket encircles the hole. The fitting has a second piece that loops around the pipe and allows for the “saddle” to be drawn tight against the pipe surface. Approval for these fittings is limited to fittings having a minimum of one pipe size reduction as the branch outlet. Equal size outlets are not permitted. The typical end connections to these fittings are threaded and grooved end.

Nipples

The term “nipple” or “pipe nipple” refers to short lengths of pipe that are used to make up the space between end connections. Pipe nipples are also used to allow the use of common fittings with the same end connections. For example, a union and valve are to be assembled together, but both are supplied with female threaded connections, so a pipe nipple is used to connect them both.

Plain End Coupling

Pipe couplings designed to work with pipe ends that have been cut perpendicular to its axis and incorporating no grooves or threads. The coupling is typically fastened to the pipe by mechanical means, such as a fastener.

Plain End Fittings

Pipe fittings designed to work with pipe ends that have been cut perpendicular to its axis and incorporating no grooves or threads. The fitting is typically fastened to the pipe by mechanical means, such as a fastener.

Pipe Schedule

The commonly accepted reference indicating a specified wall thickness for a given nominal pipe size. Traditional steel 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.

Plugs

A plug is a threaded fitting that is used to block off an opening in the piping system, or threaded port on pressure retaining parts. The characteristic feature of a plug is that the fitting is supplied with external threads.

Rated Working Pressure

This is the maximum pressure rating that the pipe coupling or fitting is intended to operate at for its entire design life. This value sets the basis for the testing described in Section 4.

Rolled Groove

This term refers to the end connections where there is 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 rolled shoulder end connections that may be formed on similar equipment.

Rolled Shoulder

This term refers to the end connection where there is a groove that is formed radially outward from the pipe surface. Unlike traditional shoulder end joints, the rolled shoulder joint has the shoulder located a distance in from the end of the pipe like a rolled groove joint mentioned above. Since the rolled shoulder joint is outward from the pipe outside diameter, where the traditional grooved end connection is formed inward from the pipe diameter, these two styles of connections are not interchangeable without a transition piece. All connections shall be made per the manufacturer's specification for rolled shoulder dimensions.

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-2000. 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, Approval of pipe couplings and/or fittings with Schedule 40 pipes manufactured under the specifications of other national or international standards must be specified in the listing in the FM Approvals' Approval Guide using the title of the standard to which the pipe was manufactured. For the purposes of this standard, dimensional values of Schedule 40 pipe and pipes of similar outside diameter and wall thickness have been listed in Appendix E. FM Approved end connections for Schedule 40 steel pipes 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-2000. 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, Approval of pipe couplings and/or fittings with Schedule 30 pipes manufactured under the specifications of other national or international standards must be specified in the listing in the FM Approvals' Approval Guide using the title of the standard to which the pipe was manufactured. FM Approved end connections for Schedule 30 steel pipes are: threaded (for NPS 8 and above), 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-2000. 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, Approval of pipe couplings and/or fittings with Schedule 10 pipes manufactured under the specifications of other national or international standards must be specified in the listing in the FM Approvals' Approval Guide using the title of the standard to which the pipe was manufactured. FM Approved end connections for Schedule 10 steel pipes 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-2000. 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, Approval of pipe couplings and/or fittings with Schedule 5 pipes manufactured under the specifications of other national or international standards must be specified in the listing in the FM Approvals' Approval Guide using the title of the standard to which the pipe was manufactured. For the purposes of this standard, dimensional values of Schedule 5 pipe have been listed in Appendix E. FM Approved end connections for Schedule 5 steel pipes are: welded, roll grooved*, plain end. (* - Limited Approval of rolled grooved connections. Refer to the listings of the pipe couplings or fittings, in the Approval Guide, for specific mention of their suitability for use with Schedule 5 pipe.)

Segmentally Welded Fittings

Any fitting that is fabricated by welding pipe segments together in the shape of other common fittings. For example, pipe segments welded together to form an elbow. Segmentally welded fittings are typically supplied with grooved end connections.

Short Radius Elbows and Tees

A short radius tee or elbow is characterized by having a bend radius that is smaller than a standard elbow or tee.

Shouldered End

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.

Slip-On Flange

A slip-on flange is a metal ring that is supplied pre-drilled with a bolt hole pattern that slips over the outside diameter of the pipe. The pipe end is subsequently flared out, thus retaining the flange.

Sweep Elbow

A sweep elbow is a fitting that has been made from mechanically forming a straight section of pipe into the shape of an elbow. These fittings typically have lower friction loss due to a larger bend radius as compared to a standard cast elbow.

Tee

A tee is a fitting that is either cast or fabricated and is characterized by two ends inline (run) and one end connection perpendicular (branch). These fittings are available with threaded, flanged, grooved, or plain end connections.

Tee, Bull Head

A bull head tee is similar to the standard tee with the exception that the branch outlet is of a larger nominal pipe size than the run outlets. The common end connections for bull head tees are grooved, threaded and flanged.

Tee, Street

A street tee is similar to a standard tee with the exception that the branch outlet is of a different type of end connection. For example, a 1 inch NPS street tee would be supplied with female threaded run connections and a male threaded branch outlet. The street tee is typically supplied with threaded ends.

Threaded End

Pipe couplings or fittings which have been furnished with its ends threaded with internal or external pipe threads conforming to national or international standards for pipe threads for the nation of intended use (i.e. ANSI B1.20.1, ISO 7/1).

Thinwall Pipe

Thinwall pipe is characterized by having a combination of outside diameter and wall thickness that may be suitable for threading but not suitable for cut grooving. Threadable thinwall pipe typically has outside diameter dimensions less than Schedule 40 pipe, however the wall thickness ranges between that of Schedules 10 and 40 and may vary from manufacturer to manufacturer. The normal end connections for Thinwall pipe are: threaded, roll grooved, welded, or plain end.

Union – Flat and tapered seat

A union is an assembly of components that are used to join two lengths of pipe together. The unique feature of a union is that there are two ends that thread onto the ends of the pipe, and a large nut that is retained on one fitting, and threads onto the second end thus joining the two pipes. Unions provide the ability of allowing for rotation along the pipe axis before the retaining nut is tightened. The seal for this fitting is created by either the compression of the internal tapered male and female end components, or by the compression of a flat seal retained within one of the components.

Welded Branch Outlet Fitting

A welded branch outlet fitting is a component that is used to make a perpendicular connection to a length of pipe. A hole is predrilled into the pipe wall, and the welded branch outlet fitting is then placed directly over the hole, and welded to the pipe. These fittings are commonly available with threaded and grooved outlet, and either flat or saddle like welding ends.

Welding End

Steel pipe furnished with weld ends are characterized by having the ends cut perpendicular to its axis and finished with a pronounced bevel on each end to allow for buttwelding.

Wye, Tee

A wye tee is a fitting that is composed of a straight run and an angled branch outlet. The unique feature of this type of fitting is that the outlet of the branch is perpendicular to the axis of the straight run of the fitting initially, and then angled.

Wye, True

A true wye fitting is a fitting that is composed of a straight run and an angled branch outlet. The end connections of a true wye share the same axis relative to their position on the fitting (i.e. the ends of the run are on the axis of the run, the end of the branch is on the axis of the branch.

2. GENERAL INFORMATION

2.1 Product Information

2.1.1 The products outlined in Section 1.2 of this standard are for use in aboveground fire protection systems. Installations shall be in accordance with FM Global Property Loss Prevention Data Sheets and the manufacturer's installation instructions.

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

2.2 Approval Application Requirements

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

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

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

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration,
- General assembly drawings, one complete set of manufacturing drawings, materials list(s) (e.g,, ASTM A 48, Class 40A, Gray Iron Casting), anticipated marking format, brochures, sales literature, specification sheets, installation, operation and maintenance procedures, and
- The number and location(s) of manufacturing facilities.

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

2.3 Requirements for Samples for Examination

Following set-up and authorization of an Approval examination, the manufacturer shall submit samples for examination and testing. Sample requirements are to be determined by FM Approvals following review of the preliminary information. Sample requirements may vary depending on design features, results of prior testing, and results of the foregoing tests. It is the manufacturer's responsibility to submit samples representative of production. Any decision to use data generated utilizing prototypes is at the discretion of FM Approvals. The manufacturer shall provide any special test fixtures, which may be required to evaluate the gasketed pipe coupling or other pipe fitting.

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 product shall be capable of being used within the limits of the Approval investigation.

3.1.2 The manufacturer's dimensional specifications and / or design drawings shall fully describe the product. All critical dimensions shall be indicated with allowed upper and lower tolerance limits 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 drawings shall be provided with an English translation.

3.2 Physical or Structural Features

3.2.1 Grooved end couplings, and all other pipe fittings shall be designed for a minimum rated working pressure of 175 psi (1205 kPa) for use in fire protection systems. Higher ratings are at the manufacturer's option and will be examined on a case-by-case basis.

3.2.2 The dimensions for grooved end connections shall be per the manufacturer's specified dimensions. The following table outlines the minimum pipe schedules to be used for cut and roll grooving.

Table 3.2.2 *Minimum Pipe Schedules for Cut and Roll Grooving*

Nominal Pipe Size, in.	***Grooving Method***	***Minimum Pipe Schedule to be Joined***
6 or smaller	Cut	Schedule 40
8 or larger	Cut	Schedule 30
2 or smaller	Rolled	Schedule 5
6 or smaller	Rolled	Schedule 10, Thinwall, Lightwall
8 or larger	Rolled	0.188 in. (4.8 mm) wall

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

3.2.4 Threaded end connections shall be in accordance with ASME B1.20.1, EN 10226, ISO 7/1 or other recognized national or international standards for their country of use.

3.2.5 Approval examinations of pipe couplings and fittings for use on galvanized pipe shall include a representative sampling of tests conducted on joints using galvanized pipe.

3.2.6 No special tools shall be required for the installation of the gasketed pipe coupling, or plain end fittings discussed in this Approval standard. Tools for fitting assembly shall be the subject of a special examination.

3.2.7 Gasketed pipe couplings and pipe fittings discussed in this Approval standard shall provide water and air-tight joints between pipe segments, or valves and fittings and are expected to exhibit a service life at least equal to the traditional pipe fittings used in a fire protection system.

3.2.8 Assemblies submitted for testing shall be true production samples and shall be free of sharp edges, burrs, or other imperfections which might injure the installer or interfere with proper assembly of the unit.

3.2.9 If a dry area of a sprinkler system is exposed to fire, all usual materials can be expected to be destroyed by prolonged fire exposure. Hence, the design of the coupling or fitting shall be such that a joint shall not leak in excess of the discharge from one sprinkler, as defined in Section 4.11.2, if the gasket is completely removed. Such leakage would not be expected to destroy the effectiveness of a properly design sprinkler system.

3.2.10 Plain end fittings shall have a positive visual means to identify that the required assembly torque has been applied to the fasteners.

3.3 Materials

3.3.1 All materials used in the products identified in this Approval Standard shall be suitable for the intended application. In no cases shall the use of alloy materials with melting points under 1470 °F (800°C) be used as the primary means of pressure retention. When unusual materials are used, special tests may be necessary to verify their suitability.

3.3.2 Products identified in this Approval Standard shall be constructed of corrosion resistant materials. Alternatively, the products may be supplied as painted or galvanized to meet this requirement. For the cases where products are supplied bare, such as ductile iron flanged fittings which have a built in corrosion allowance factored into the design, an anti-rust coating shall be supplied to the part to reduce the chance for surface rust.

3.3.3 Gasket material shall be suitable for both continuous water and air service in the temperature range of -40° to 225° F (-40° to 107°C). They shall be pliable, smooth, and free of obvious surface porosity and mold flash. The normal material for the gaskets has historically been Ethylene Propylene Diene Monomer (EPDM Type A). Other gasket materials may be considered for FM Approval, but will be subject to special investigation based on the material properties, and the intended application.

3.4 Markings

3.4.1 Grooved Couplings, Grooved Split Flanges, Mechanical Tees

3.4.1.1 The following data shall be cast, forged, or embossed on the outside surface of each grooved coupling, grooved split flange, and mechanical tee assembly. Not all markings need appear on each piece of a multi-component assembly, as long as all information is complete. Products which cannot be completely marked due to their size shall have, at minimum, the first four items shown below:

- Manufacturer’s name or trademark;
- Product model number;
- FM Approvals Certification Mark (See Appendix B);
- Nominal pipe size;
- Manufacturing source code, if made at more than one location;
- Required bolt size (for grooved split flanges);
- Assembly torque (for mechanical tees); and,
- Any additional information required by the national or international standard to which it is manufactured.

3.4.1.2 The following markings may alternately be on the inside of the product:

- Manufacturing source code, if made at more than one location;
- Cavity number; and,
- Date code/Heat code

3.4.1.3 If gaskets are available in different materials, each material shall be clearly coded to identify their compounds (i.e. color codes, letter material codes, or both).

3.4.1.4 A corrosion resistant metal nameplate bearing the same information as stated above shall be considered acceptable if permanently fastened to the grooved coupling.

3.4.1.5 If the mechanical tees discussed in this standard are supplied with threads conforming to multiple industry standards, the mechanical tee must carry an additional mark to signify the thread profile used. Examples of the additional marking are: an alternate product designation, or color code, or other permanent mark to signify the alternate thread profile used. For a given product designation, if a standard thread profile has been stated by the manufacturer in their literature, then the standard product would be exempt from the requirement of the additional mark, and only product with alternate threads would need to be marked.

3.4.2 Fittings

3.4.2.1 The following data shall be cast, forged, or embossed on the outside surface of each fitting or fitting assembly. Not all markings need appear on each piece of a multi-component assembly, as long as all information is complete. However, all information must be visible without disassembly, if the size of the product permits said marking:

- Manufacturer's name or trademark;
- Product model number;
- FM Approvals Certification Mark;
- Nominal pipe size;
- Manufacturing source code, if made in more than one location; and,
- Any additional information required by the national or international standard to which it is manufactured.

3.4.2.2 When small fitting size does not permit complete markings as identified above, all missing information shall be imprinted upon labels affixed to the smallest shipping and packing containers.

3.4.2.3 If threaded fittings discussed in this standard are supplied with threads conforming to multiple industry standards, the fitting shall carry an additional marking to signify the alternate thread profile used. Examples of additional markings are: alternate product designations, color codes, or other permanent marking. For a given product designation if a standard thread profile has been stated by the manufacturer in their literature, then the standard product would be exempt from the requirement of the additional mark, and only product with alternate threads would need to be marked.

3.4.2.4 A corrosion resistant metal nameplate bearing the same information as stated above shall be considered acceptable if permanently fastened to the fitting.

3.4.3 Manufacturer's literature shall indicate the rated working pressures for the FM Approved products. The rated working pressures for the FM Approved product shall be clearly identified and not confused with the commercial pressure ratings obtained by testing to other requirements.

3.4.4 Each required marking listed shall be legible and durable and applied in any of, or combination of, the above methods. Other methods of applying permanent markings will be evaluated on a case by case basis.

3.4.5 The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The FM Approvals Certification Mark (see Appendix B) shall be displayed visibly and permanently on the product. The manufacturer shall not place this model or type identification on any other product unless covered by a separate agreement with FM Approvals.

3.5 Manufacturer's Installation and Operation Instructions

3.5.1 The installation instructions, including any special requirements for: dimensions, pipe preparation, cleanliness, lubrication, bolt torque, or use of installation tools shall be made available to the installer. This requirement may be satisfied in the form of manufacturer’s literature, product handbooks, or website.

3.5.2 The installation instructions identified in Section 3.5.1 shall be made available in multiple languages in support of the regions where the product is intended to be sold.

3.6 Calibration

All equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage of equipment. A copy of the calibration certificate for each piece of test equipment is required for FM Approvals records, indicating that the calibration was performed against working standards whose calibration is certified as traceable to the National Institute of Standards and Technology (NIST) or to other acceptable reference standards and certified by a ISO 17025 calibration laboratory. The test equipment must be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service accreditation certificate as an ISO 17025 “General Requirements for the Competence of Testing and Calibration Laboratories”, calibration laboratory is required for FM Approval records.

The calibration of recently purchased new equipment is also required. Documentation indicating either the date of purchase or date of shipment, equipment description, model and serial number is required for identification. The period from the time the equipment was put into service to the date of the testing must be within an interval that does not require the equipment to be calibrated as determined on the basis of the parameters mentioned above.

3.7 Tolerances

Tolerances on units of measure shall be as described in Appendix H, unless otherwise specified.

4. PERFORMANCE REQUIREMENTS

4.1 Examination

4.1.1 Requirements

Gasketed pipe couplings and other pipe fittings shall conform to the manufacturer's drawings and specifications and to FM Approvals' requirements.

4.1.2 Test/Verification

Samples shall be examined and compared to drawings and specifications. It shall be verified that the samples conform to the physical and structural requirements described in Section 3, General Requirements, and the manufacturer's drawings. The manufacturer's installation instructions shall be reviewed for completeness and ease of understanding.

4.2 Hydrostatic Strength

4.2.1 Requirement

All items FM Approved under this standard 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 Test/Verification

Compliance shall be verified by testing representative assemblies of each size and model submitted for Approval. The testing shall address each size of the product under evaluation, and the applicable pipe schedules. It is allowed for this testing to be performed using multiple joints along the same pipe, or individual assemblies for each joining method. Products for use with galvanized pipe shall be tested using representative samples of galvanized pipe. Pipe segments between test joints, when required, shall be approximately 1 ft (0.3 m) long each. Assemblies shall be subjected to a hydrostatic test of a minimum of 700 psi (4830 kPa), or four times the rated working pressure of the products under evaluation, whichever is greater. The test shall be conducted for a duration of five minutes. The test pressure for each assembly shall be four times the lowest rated working pressure of any component of the assembly. FM Approvals 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 one joint assembly.

4.3 Bending Moment Resistance

4.3.1 Requirements

Grooved end couplings, grooved reducing couplings, grooved split flanges, and plain end coupling assemblies shall demonstrate bending moment resistance, without leakage, fracture, or fitting or coupling pull-off at the moments 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 grooved end coupling or fitting, or pipe, 175 psi (1205 kPa) minimum. The bending moment assemblies tested shall be representative of each size and schedule of pipe under consideration for Approval.

4.3.2 Tests/Verification

4.3.2.1 Compliance shall be verified by testing representative assemblies of each type of grooved end coupling, grooved reducing coupling, grooved split flange and plain end coupling, centered between two lengths of pipe. Products for use with galvanized pipe shall be tested using representative samples of galvanized pipe. The outer ends of the assemblies shall be suitably capped and provided with pressurization and venting connections. Each assembly shall be supported on a test fixture, with the joint of interest centered on that span. Force shall be applied to the center of the joint, tending to deflect the assembly until the minimum required bending moment is reached. Bending moment resistance shall be demonstrated while the test assembly is internally pressurized to the rated working pressure of the grooved end coupling or fitting, or pipe, 175 psi (1205 kPa) minimum. The bending moment tables in Appendix E list the required bending moments and three common sizes of bending moment fixtures. It is not necessary to test at each of the support spacings listed. Figure C-2 illustrates the required test configuration for pipes 1 in. (25 mm) and larger.

4.3.2.2 The required bending moments have been calculated from the weights of water-filled Schedule 40 pipe, the maximum hanger spacing allowed for sprinkler systems (assuming that one hanger is missing) and a safety factor of two. Currently 1-1/4 in. NPS and smaller pipe is installed with a maximum hanger spacing of 12 ft. (3.6 m). Pipe sizes 1-1/2 inch NPS and larger are allowed hanger spacing no greater than 15 ft. (4.6 m). (Note: Installation rules for threadable Thinwall pipe may require hanger spacing to be less than 15 ft (4.6 m) depending on where it is installed. For the purposes of defining the requirement, we have elected to use 12 ft (3.6 m) hanger spacing for 1-1/4 inch NPS and smaller, and 15 ft (4.6 m) hanger spacing for sizes 1-1/2 and larger.) 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 different hanger spacing from 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 spacing of hangers into account. An example of bending moment calculations has been illustrated in Appendix D. Pipe designed per SI unit standards shall withstand bending moments as listed in Appendix E.

4.3.2.3 For Approval testing using pipe that is manufactured to specifications that do not define "Schedules", such as DIN EN 10220-03, or EN 10255 Approval 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 variances in pipe and waterway volume. For this case, the bending moments will be calculated for the lowest and highest pipe wall thicknesses and compared to the Schedule 40 values tabulated in Appendix E. If the calculated values are higher than the values in Table E for Schedule 40, then these samples will be subjected to a bending moment test using the calculated values conducted on short lengths of pipe with the lower pipe wall thickness.

4.3.2.4 Bending moment testing is also required when using pipe that is manufactured with different outside diameters than those of Schedule 40 such as the larger sizes of pipe manufactured to the dimensional values of JIS G3454. This is to account for the case where pipes with different outside diameters are joined.

4.3.2.5 The only exception to Schedule 40 bending moments is Schedule 5 pipe, which is limited to use in branch line service, with specialized fittings, and should never be connected to Schedule 40 pipe. Bending moments for Schedule 5 pipe, with specialized fittings, have been tabulated in Appendix E, Table E-4. Bending moments for Schedule 5 pipe, with specialized fittings are based on water filled Schedule 40 pipe, and 12 ft hanger spacing independent of pipe size.

4.3.2.6 For reducing couplings, the bending moment to be used shall be based on the smaller coupled pipe size.

4.3.2.7 There are no bending moment values for 1/2 and 3/4 in. nominal size pipe fittings as they are only used in accessory lines. Figure C-2 illustrates the required test configuration for pipes 1 in. (25 mm) NPS and larger.

4.3.2.8 There shall be no leakage, cracking, or fitting or coupling pull-off as a result of this test.

4.4 Rotational Bending Moment Resistance

4.4.1 Requirement

Mechanical tees and welded outlet fittings shall maintain local structural integrity when used with FM Approved pipe schedules for which Approval is sought. Products for use with galvanized pipe shall be tested using representative samples of galvanized pipe. The maximum permitted outlet size is one pipe size reduced from the run size. Each tee-shaped assembly shall be subjected to a rotational bending moment tending 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 fitting or pipe, 175 psi (1205 kPa) minimum.

4.4.2 Test/Verification

4.4.2.1 Compliance shall be verified by testing representative assemblies of each nominal pipe size of mechanical tee, mechanical cross, or welded outlet fittings under consideration for Approval. The test assemblies shall be composed of mechanical tees, mechanical crosses, or welded outlet fittings of the largest permitted branch size. The run pipe shall be held rigidly, and a force shall be applied to the branch pipe sufficient to apply the rotational bending moment shown in Appendix F based on the 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 manufacturer for the two tests.

4.4.2.2 When an applied rotational bending moment causes a fitting or coupling to rotate (slip) around the run pipe without reaching the required rotational bending moment value, the fitting shall be allowed to rotate through 90° of travel, moving the run pipe as necessary. The fitting or coupling shall remain leak tight while pressurized to its rated working pressure, before, during, and after the 90° rotation irregardless of whether the rotational bending moment is achieved.

4.5 Vibration Resistance

4.5.1 Requirement

Grooved end couplings, grooved reducing couplings, grooved split flanges, mechanical tees, and plain end couplings shall withstand the effects of vibration without cracking, rupture, leakage, or movement from its originally installed location. For the case of grooved end couplings, reducing couplings, and grooved split flanges, movement is defined as outside the extents of the groove. Following the vibration test detailed in Section 4.5.2 the joint shall not leak when tested in accordance with the requirements of Section 4.2, (Hydrostatic Strength).

4.5.2 Tests/Verification

Compliance shall be verified by tests of representative assemblies of each type of grooved end coupling or pipe fitting under examination. Products for use with galvanized pipe shall be tested using representative samples of galvanized pipe. 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 joint leakage or other failure is allowed during this 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 at any pressure less than or equal to four times the pressure rating of the pipe, coupling, or fitting, whichever takes precedence, for a duration of five minutes.

Table 4.5.2 *Vibration Conditions*

Total Stroke		***Frequency***	***Time***
in.	***(mm)***	***Hz***	***Hours***
0.020	(0.51)	28	5
0.040	(1.04)	28	5
0.150	(3.81)	28	5
0.040	(1.04)	18 to 37 (variable)	5
0.070	(1.78)	18 to 37 (variable)	5

4.6 Cycling Pressure Resistance

4.6.1 Requirements

Representative assemblies of grooved couplings, reducing couplings, grooved split couplings and mechanical tees shall withstand the effects of cycling pressure without cracking, rupture, leakage, or movement from its original installed location. For the case of grooved end couplings, reducing couplings, grooved split flanges, movement is defined as outside the extents of the groove. Prior to the cycling, assemblies shall be subjected to a hydrostatic strength test to the rated working pressure, 175 psi (1205 kPa) minimum, for a duration of 5 minutes. Assemblies shall then be subjected to 20,000 cycles from zero pressure to the rated working pressure, 175 psi (1205 kPa) minimum. After cycling, the test assembly shall be tested in accordance with Section 4.2, (Hydrostatic Strength).

4.6.2 Tests/Verification

4.6.2.1 Compliance shall be verified by testing of representative samples of each size, type of joint, and schedule of pipe under examination. It is recommended that products be grouped into assemblies for this test. Where possible, the test assemblies should incorporate joints involving cast, cut, and rolled grooves for grooved end products. Products for use with galvanized pipe shall be tested using representative samples of galvanized pipe.

4.6.2.2 Prior to cycling, the test assembly shall be subjected to an internal pressure equal to the rated working pressure of the lowest rated component in the assembly, 175 psi (1205 kPa) minimum. This test shall be conducted for a duration of five minutes. No leakage, rupture, or cracking is allowed.

4.6.2.3 Assemblies shall be subjected to 20,000 cycles from zero pressure to the rated working pressure, 175 psi (1205 kPa) minimum. The test equipment shall be equipped with a means of counting the pressure cycles.

4.6.2.4 After cycling, the hydrostatic test of Section 4.2 shall be repeated. No leakage, cracking, or rupture shall be observed at any pressure less than, or equal to, four times the pressure rating of the lowest rated component of the assembly. This test shall be conducted for a duration of five minutes.

4.7 Vacuum Resistance

4.7.1 Requirement

Grooved couplings, grooved reducing couplings, grooved split flanges, mechanical tees, and plain end couplings shall be able to withstand the effects of vacuum conditions encountered when sprinkler systems are drained. Samples of each nominal size and style of gasketed coupling and fitting shall be subjected to an internal vacuum of 25 inHg (85 kPa) for a duration of 5 minutes. Following the vacuum test, the test assembly shall be pneumatically pressurized from zero to 50 psi (345 kPa) while submerged in a water bath. There shall be no leakage or permanent deformation as a result of this test.

4.7.2. Tests/Verification

Using a sample assembly similar to that required for the vibration resistance test, Section 4.5, the test assembly shall be filled with water and subjected to an internal pressure equal to the rated working pressure for a duration of five minutes. The sample shall then be drained and subjected to an internal vacuum condition of 25 inHg (85 kPa) for five minutes. Following the vacuum test, the test assembly shall be pneumatically pressurized from zero to 50 psi (354 kPa) while submerged in a water bath. There shall be no leakage or permanent deformation as a result of this test.

4.8 Hot Gasket Test

4.8.1 Requirement

Standard EPDM gasketed couplings shall be designed for a -40° to 225°F (-40° to 107°C) temperature service range. Other rubber compounds may also be FM Approved provided that the requirements in Section 4.8.2.2 are met. Samples of each style gasket shall be subjected to hot gasket testing in order to evaluate conformance to this requirement. Standard gaskets shall be assembled to short lengths of pipe, and subjected to 275°F (135°C) for a duration of 45 days. After exposure, the test assembly shall be submerged in a water bath and subjected to an air under water leakage test from zero to 50 psi (0 to 345 kPa) in order to evaluate for leakage. After the air under water testing is completed, the test assembly shall be disassembled and the gasket shall not crack when squeezed together from any two diametrically opposite points, or twisted into a figure-eight shape. The gasket shall then be visually inspected for signs of cracking, tearing, or excessive degradation as a result of this test.

4.8.2. Tests/Verification

4.8.2.1 Standard Grade EPDM Gaskets: Representative samples of each style gasket shall be subjected to hot gasket testing to evaluate conformance with the requirements. The gasketed fittings shall be assembled to short lengths of steel pipe and lubrication shall be applied per the manufacturer's instructions. The free ends of the test assembly shall be closed off by suitable means such as: grooved end caps, threaded caps or plugs, or blind flanges. The test assembly shall be filled with water making sure to remove all internal air. Once full, the test assembly shall be connected to a hydrostatic pressure pump and the internal pressure shall be increased to the rated working pressure for a duration of five minutes. After five minutes at the rated working pressure, the internal pressure shall be released and the test assembly shall be disconnected from the pump, and drained. When drained, the sample shall be placed in an air circulating oven set at 275°F (135°C) unpressurized for a period of 45 days. At the conclusion of the high temperature exposure, the test assembly shall be removed from the air circulating oven and allowed to cool to room temperature 73°F (20°C) prior to leakage

testing. After the sample has reached room temperature 73°F (20°C), the assembly shall be connected to a controlled source of compressed air and submerged in a water bath. The internal air pressure in the sample shall then be raised from 0 to 50 psi (0 to 345 kPa) over the course of 2 minutes, while the sample is visually checked for leakage. No leakage shall occur. Upon successful completion of the leakage test, the test assembly shall be disassembled. The gasket shall be visually examined for flexibility and signs of degradation as a result of the temperature exposure. If the gasket adheres to the pipe or the fitting body, a careful attempt shall be made to remove the gasket from the surfaces. Any tears resulting from disassembly shall not be considered as a failure. Once free, the gasket shall be visually examined for cracking or tearing when squeezed from any two diametrically opposed points, or twisted into a figure-eight shape.

4.8.2.2 Gaskets made from other materials may also be evaluated on a case by case basis. If the alternate material is capable of withstanding the test outlined in Section 4.8.2.1, such as silicone, then the test will be performed in accordance with Section 4.8.2.1. In the event that the material is not able to withstand the test in Section 4.8.2.1, then the material will be subjected to a special investigation based on the material properties, manufacturer's statement of life expectancy, and time versus degradation curves for compression set, stress relaxation, degradation temperature, and recommended service temperature.

4.9 Cold Gasket Test

4.9.1 Requirement:

The low temperature exposure shall consist of -40 °F (-40 °C) air exposure for 4 days. After exposure, the assembly while submerged in -40 °F (-40 °C) antifreeze, shall be pneumatically pressurized from 0 to 50 psi (0 - 345 kPa). No leakage shall occur. The assembly shall then be allowed to warm to ambient temperature and then be disassembled. The gasket, after removal from the assembly, shall not crack when squeezed together from any two diametrically opposite points, or twisted into a figure-eight shape.

4.9.2 Test / Verification:

4.9.2.1 Representative samples of each style gasket shall be subjected to cold gasket testing to evaluate conformance with the requirements. The gasketed fittings shall be assembled to short lengths of steel pipe and lubrication shall be applied per the manufacturer's instructions. The free ends of the test assembly shall be closed off by suitable means such as: grooved end caps, threaded caps or plugs, or blind flanges. The test assembly shall be filled with water making sure to remove all internal air. Once full, the test assembly shall be connected to a hydrostatic pressure pump and the internal pressure shall be increased to the rated working pressure for a duration of five minutes. After five minutes at the rated working pressure, the internal pressure shall be released and the test assembly shall be disconnected from the pump, and drained. When drained, the sample shall be placed in an air circulating freezer set at -40°F (-40°C) unpressurized for a period of 4 days. At the conclusion of the cold temperature exposure, the test assembly shall be removed from the air circulating freezer and quickly submerged in a -40°F (-40°C) antifreeze solution prior to leakage testing. The assembly shall be connected to a controlled source of compressed air and submerged in the antifreeze bath. The internal air pressure in the sample shall then be raised from 0 to 50 psi (0 to 345 kPa) over the course of 2 minutes, while the sample is visually checked for leakage. No leakage shall occur. Upon successful completion of the leakage test, the test assembly shall be disassembled. The gasket shall be visually examined for flexibility and signs of degradation as a result of the temperature exposure. If the gasket adheres to the pipe or the fitting body, a careful attempt shall be made to remove the gasket from the surfaces. Any tears resulting from disassembly shall not be considered as a failure. Once free, the gasket shall be visually examined for cracking or tearing when squeezed from any two diametrically opposed points, or twisted into a figure-eight shape.

4.9.2.2 Gaskets made from other materials may also be evaluated on a case-by-case basis. If the alternate material is capable of withstanding the test outlined in Section 4.9.2.1, such as silicone, then the test will be performed in accordance with Section 4.9.2.1. In the event that the material is not able to withstand the test in Section 4.9.2.1, then the material will be subjected to a special investigation based on the material properties, manufacturer's statement of life expectancy, and time versus degradation curve, curves for compression set, stress relaxation, degradation temperature, and recommended service temperature.

4.10 Fire Test

4.10.1 Requirement

Gasketed pipe couplings and fittings made from non-ferrous materials shall have sufficient fire resistance to prevent joint failure.

4.10.2. Tests/Verification

If a gasketed pipe coupling or fitting employs non-ferrous materials for its substantial structural components, or if in the judgment of FM Approvals, the design is otherwise suspect with respect to fire resistance, a fire test shall be conducted. A representative size assembled joint without a gasket shall be exposed to a 1000 °F (538 °C) fire environment for 5 minutes. The assembly shall be dry for the duration of this exposure. Immediately after the exposure, a water flow shall be introduced through the joint and sustained until the assembly is cool to the touch. No cracking or distortion of any component of the coupling or fitting shall occur. The coupling or fitting shall then be disassembled and the gasket installed. After reassembly, the joint shall be hydrostatically tested, as described in to the hydrostatic test of Section 4.2.

4.11 Leakage Test - Assembly without Gasket

4.11.1 Requirement

Leakage from a gasket-less coupling assembly or fitting shall not exceed that of an operating sprinkler head whose discharge coefficient (K-factor) is 5.3 to 5.8 gal/min(psi)$^{1/2}$ [76 - 84 L/min/(bar)$^{1/2}$].This test is for nominal pipe sizes normally associated with over-head piping, less than or equal to 12 in. NPS (300 mm).

4.11.2. Tests/Verification

A sample coupling or fitting, assembled connecting two lengths of pipe, but without its gasket, shall not demonstrate leakage in excess of that to be expected from a single sprinkler having a discharge coefficient of 5.3 to 5.8 in United States Customary units. Leakage shall not exceed 32 gal/min (120 L/min) at 30 psi (205 kPa) internal water pressure. The test shall be performed on, at minimum, the largest and smallest size coupling or fittings submitted for Approval.

4.12 Friction Loss Determination

4.12.1 Requirement

The construction and installation of the coupling or fitting shall be such that obstruction to the passage of water through the coupling or fitting body is minimal. The loss in pressure through the coupling or fitting shall not exceed 5.0 psi (35 kPa) at a flow producing a velocity of 20 ft/s (6.1 m/s) in Schedule 40 steel pipe of the same nominal diameter as the coupling or fitting.

4.12.2 Tests/Verification

During examination of devices such as saddle tees, welded branch outlet fittings, and the like, where a portion of the device may be installed into a hole in the pipe, a comparison of the outlet waterway area to that of Schedule 40 steel pipe or a sprinkler will be made. Should the open waterway be less than, equal to, or marginally larger than that of steel pipe or a sprinkler, friction loss (a.) or K-factor (b.) testing shall be performed at the discretion of FM Approvals to evaluate the flow characteristics of the product. Products which are an impediment to the free flow of water to a sprinkler cannot be FM Approved.

a. Install the fitting on a length of pipe and subject to a flow rate resulting from a nominal line velocity of 20 ft/sec (6.1 m/s) with the water flow direction originating in the pipe and exiting the fitting. Measure the pressure drop through the fitting. The pressure drop shall not exceed 5 psi (35 kPa) at 20 ft/s (6.1 m/s) flow.

b. Two previously untested samples shall be tested using the test set-up for determining K-factor at increasing and decreasing pressures from 15 to 50 psi (105 to 345 kPa) in 5 psi (35 kPa) increments, 60 to 100 psi (415 to 690 kPa) in 10 psi (70 kPa) increments, and 125, 150, and 175 psi (860, 1035, and 1205 kPa).

The discharge coefficient (K) shall be determined using the expression:

$$K = \frac{Q}{P^{1/2}}$$

Where Q = flow rate [gal/min (L/min)] and P = pressure [psi (kPa)].

After the discharge coefficient test has been completed, the collected data shall be compared to the values in the table below in order to access compliance. Compliance with the requirement will result in an observed discharge coefficient in excess of the values in the table below.

Nominal Pipe Size Outlet, inch (mm)	***Discharge Coefficient***	
	gal/min/(psi)$^{1/2}$	***L/min/(bar)$^{1/2}$***
1/2 (12 mm)	11.2	166
3/4 (20 mm)	17.6	254
1 (25 mm)	26.5	382

4.13 Seismic Evaluation

4.13.1 Requirement

In order to evaluate the use of grooved couplings in FM Global Earthquake zones 50 through 500 years, test assemblies utilizing flexible couplings and short lengths of steel pipe, in the same nominal size, will be subjected to cyclic testing. The test will deflect the assembly to the manufacturer's maximum recommended angle in the forward and reverse direction for a total 15 cycles with the internal pressure equal to the rated working pressure. There shall be no leakage, cracking, or rupture as a result of this test.

4.13.2 Tests / Verification

Using a sample assembly as shown in Appendix C, Figure C.11, the sample will be subjected to the manufacturer's maximum recommended deflection angle in the forward and reverse directions for a duration of 15 cycles at one hertz. During this testing, the sample will have an internal pressure equal to the rated working pressure. The test assembly shall be made utilizing roll grooved pipe with the lowest wall thickness under consideration for use with the grooved coupling under evaluation. There shall be no leakage, cracking, or rupture as a result of this test.

4.14 Additional Tests

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

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

5. OPERATIONS REQUIREMENTS

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

5.1 Demonstrated Quality Control Program

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

- Existence of corporate quality assurance guidelines;
- Incoming quality assurance, including testing;
- In-process quality assurance, including testing;
- Final inspection and tests;
- Equipment calibration;
- Drawing and change control;
- Packaging and shipping;
- Handling and disposition of non-conforming materials.
- In order to assure adequate traceability of materials and products, the manufacturer shall maintain records of all quality control tests performed, for a minimum period of two years from the date of manufacture.

5.1.2 Documentation/Manual

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

5.1.3 Drawing and Change Control

The manufacturer shall establish a system of product configuration control that shall not allow unauthorized changes to the product. Revisions to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production. The manufacturer shall assign an appropriate person or group to be responsible for reporting proposed revisions to FM Approved products to FM Approvals before implementation. In situations involving significant modifications to an Approved product, the notification shall be in the form of a formal request for an Approval examination. For modifications of a more common nature, the manufacturer

shall provide notification to FM Approvals by means of FM Approvals Form 797, Approved Product/Specification-Tested Revision Report or Address/ Main Contact Change Report. Records of all revisions to all FM Approved products shall be maintained.

5.1.3.1 The table below has been included as a guide to manufacturers of what is considered to be a significant change to FM Approvals. As mentioned above, modifications that fit this category should be documented by means of a letter stating the change, and requesting a quotation for an Approval examination.

Modification	***Description / Example***
Increase of Pressure Rating:	The product was originally Approved for 175 psi (1205 kPa), and now is to be evaluated to 300 psi (2070 kPa).
Increase of Allowed Usage:	The product was Approved for wet systems (black pipe), and now is to be evaluated for use in dry systems (galvanized).
Addition of Product Sizes:	The product was originally Approved for 1 - 4 inch NPS, and now Approval of 6 and 8 inch NPS is desired.
Addition or Relocation of the Manufacturing Location:	The product was originally Approved in location A, and now is desired to be made in locations A and B, or only in location B.
Major Changes to Critical Dimensions:	Modifications that would depart from the national or international standards that are used in the manufacturing of the product as originally Approved.
	Modifications that would have an effect on the use of the pipe with standardized fittings / couplings.
	Modifications that would have an effect on the ability of the product to maintain the same performance as the originally Approved product. An example of this would be a significant reduction of fitting wall thickness.

5.1.3.2 The listing below has been included as a guide to manufacturers of modifications that are commonly submitted on FM Approvals Form 797.

Modification	***Description / Example***
Change in Company Contact Information:	Name, Title, Phone Number, Fax Number, Email Address, Company Office Address, Company Name
Updating of Drawings:	The Form 797 is used to notify FM Approvals in the event of: minor dimensional changes to non-critical features, minor changes in notes, location of title block, re-creation of the same drawing on CAD, etc.
Changes in Markings:	Please describe what changes are to be made and include a drawing of the proposed marking.
Changes in Materials:	Where new material is either superior, or comparable to material used in original Approval
Updating of Documentation:	Creation of New or Revisions to Sales literature, Installation Instructions, Grooving Dimensions, Quality Manual, etc.

5.1.3.3 For the instances where the modification is difficult to categorize, manufacturers are encouraged to contact FM Approvals to discuss the nature of the change, and inquire about how to send the information to FM Approvals. The examples shown in Sections 5.1.3.1 and 5.1.3.2 are based on common examples of modifications as they relate to the manufacture of grooved end couplings and other pipe fittings.

5.2 Facilities and Procedures Audit (F&PA)

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

5.2.2 These audits shall be conducted periodically but at least annually by FM Approvals or its representatives or more frequently depending on jurisdictional requirements. At issue of this standard the Occupational and Safety Heath Administration (OSHA) of the United States Department of Labor requires audits of manufacturing sites producing products for use in hazardous locations during each quarter the product is manufactured.

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

5.2.4 In the event that all or part of the quality inspection is subcontracted, the manufacturer shall provide FM Approvals with documentation outlining the nature of the inspection, frequency, test details, and pass / fail criteria that was provided to the subcontracted company, and documentation that they have received and implemented these procedures.

5.3 Manufacturer's Responsibilities

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

5.4 Manufacturing and Production Tests

5.4.1 Test Requirement No. 1 - *Visual Inspection*

The manufacturer shall perform visual inspections on 100 percent of fitting production. The visual inspection shall look for obvious surface or casting defects that would affect the performance of the part. Samples that have defects as outlined by the manufacturer's criteria shall be scrapped.

5.4.2 Test Requirement No. 2 - *Dimensional Inspection*

The manufacturer shall perform dimensional inspection on a sampling of the production of each fitting discussed in this Approval Standard. The frequency of dimensional inspection shall be outlined in the manufacturer's quality manual including the dimensions to be checked, and the data records to be maintained. At minimum, dimensional checks shall be recorded once per shift.

5.4.3 Test Requirement No. 3 - *Leakage*

The manufacturer shall perform leakage testing on a sampling of the production of each fitting discussed in this Approval Standard. The frequency of the leakage testing shall be outlined in the manufacturer's quality manual in addition to the test pressure, test time, and the data records that shall be maintained.

5.4.4 Test Requirement No. 4 - *Quality Inspection*

Where all or part of the quality control has been subcontracted, the manufacturer shall, at a minimum, conduct sufficient oversight audits to verify continued application of the required controls.

APPENDIX A: Units of Measurement

AREA: in^2 - "square inches"; (mm^2 - "square millimeters")
$mm^2 = in^2 \times 645.16$

ft^2 - "square feet"; (m^2 - "square meters")
$m^2 = ft^2 \times 0.0929$

FLOW: gal/min - "gallons per minute"; (L/min - "liters per minute")
L/min = gal/min x 3.785

FORCE: lb - "pounds"; (N - "Newtons")
N = lb x 4.4482

LENGTH: in. - "inches"; (mm - "millimeters")
mm = in. x 25.4

ft - "feet"; (m - "meters")
m = ft x 0.3048

LIQUID: gal - "gallons"; (L - "liter")
L = gal x 3.785

L - "liter"; (dm^3 - "cubic decimeters")
$L = 1\ dm^3$

PRESSURE: psi - "pounds per square inch"; (kPa - "kilopascals")
kPa = psi x 6.895

bar - "bar"; (kPa - "kilopascals")
bar = kPa x 0.01
bar = psi x 0.06895

TEMPERATURE: °F - "degrees Fahrenheit"; (°C - "degrees Celsius")
°C = (°F - 32) x 0.556

TORQUE $lb_f \cdot ft$ - "pound force·foot"; (N·m - "Newton-meters")
$N \cdot m = lb_f \cdot ft \times 1.356$

APPENDIX B: FM Approvals Certification Marks

FM Approvals certification marks are to be used only in conjunction with products or services that have been Approved by FM Approvals and are in adherence with usage guidelines.

FM APPROVED mark:

Authorized by FM Approvals as a certification mark for any product that has been FM Approved. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

Cast-On FM Approvals marks:

Where reproduction of the FM Approved mark described above is impossible because of production restrictions, use these modified versions of the FM Approved mark. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable.

FM APPROVED mark With "C" only:

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background

FM APPROVED mark with "C" and "US":

Authorized by FM Approvals as a certification mark for any product that has been evaluated by FM Approvals in accordance with US and Canadian codes and standards. There is no minimum size requirement for the mark, but it must be large enough to be readily identifiable. The mark should be produced in black on a light background, or in reverse on a dark background.

USAGE GUIDELINES

All FM Approvals certification marks are the sole property of FM Approvals LLC ("FM Approvals") and are registered or the subject of applications for registration in the United States and many other countries. They are for use only according to these guidelines.

FM Approvals certification marks may be used only on FM Approved products and related product packaging, in advertising material, catalogs and news releases. Use of FM Approvals certification marks on such material is not a substitute for use of the complete FM Approvals certification mark on FM Approved products and/or product packaging.

No FM Approvals certification mark or aspect thereof may be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/ product lines. This includes both design aspects (the FM Approvals "diamond," etc.) and word aspects ("FM," "Approved," etc.). The use of any FM Approvals certification mark as a trademark is strictly prohibited.

The Approval Standard number or class number may not be incorporated as part of a business name, Internet domain name, or brand name/trademark for products/ product lines. For example, a company may not say "ABC Company's 4100 Fire Door is FM Approved"; the proper terminology is, "ABC Company's Fire Door is FM Approved per Approval Standard 4100."

FM Approvals certification marks, except for the FM Approvals Quality System Registration mark, may not be used on business stationery/cards/signage because this could mischaracterize the relationship with FM Approvals. Additionally, these items should not reference any FM Approvals certification mark.

Products or services may not be marketed under any mark or name similar to "FM Global," "FM Approvals" or any of the FM Approvals certification marks. Further, products or services may not be marketed to imply a relationship beyond the scope of any Approval made by FM Approvals.

When an FM Approvals certification mark is used in advertising material or on product packaging, all material must reflect the specific circumstances under which the product was FM Approved. The material must clearly differentiate between products that are FM Approved and those that are not, and may not, in any way, imply a more substantial relationship with FM Approvals.

A company may not reference the intent to submit a product for Approval or the expectation that a company will have a certain product FM Approved in the future. For example, a company may not state, "Approval by FM Approvals pending" or "Approval by FM Approvals applied for."

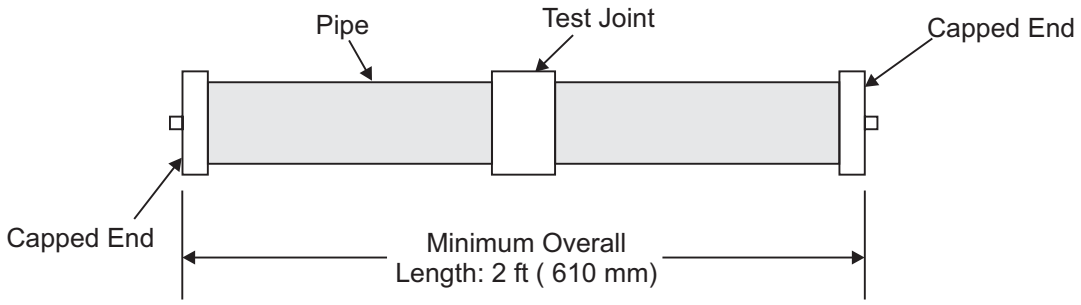
FM Approvals certification marks should not be preceded or followed by a qualifier that indicates a degree of certification or acceptability. For example, "exceeds," "first" or "only" may not be used to qualify any FM Approvals certification mark.

Only original artwork issued by FM Approvals should be used. The FM Approvals certification marks should not be altered in any way other than to resize the artwork proportionately. Unacceptable uses of the marks include, but are not limited to, adding/deleting wording or artwork, reducing the artwork to an illegible size, animation or distortion.

The text of the FM Approvals certification marks may not be translated into any language other than English.

FM Approvals certification marks must appear in a size and location that is readily identifiable, but less prominent than the name of the owner of the certification or the manufacturer/seller/distributor of the certified products.

APPENDIX C: Test Assembly Sketches



End caps should 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-1. Hydrostatic Test

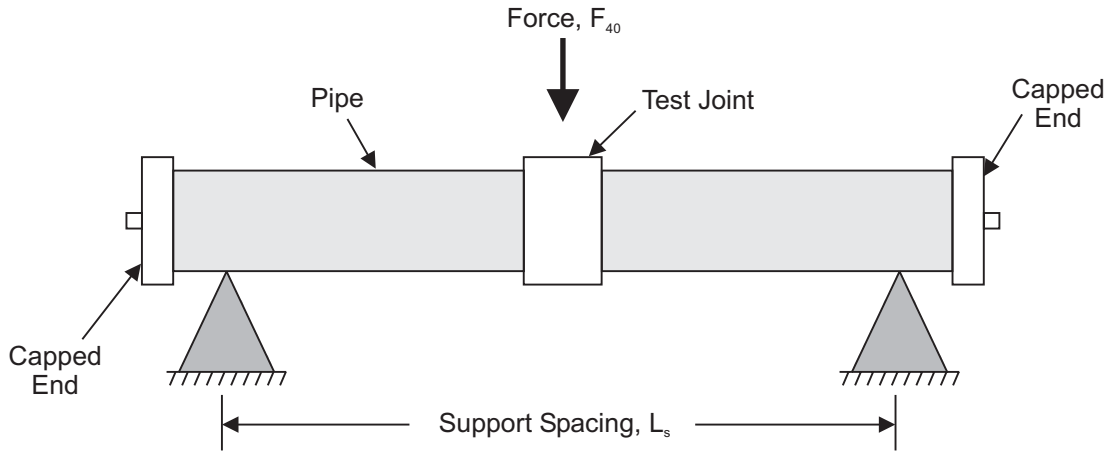
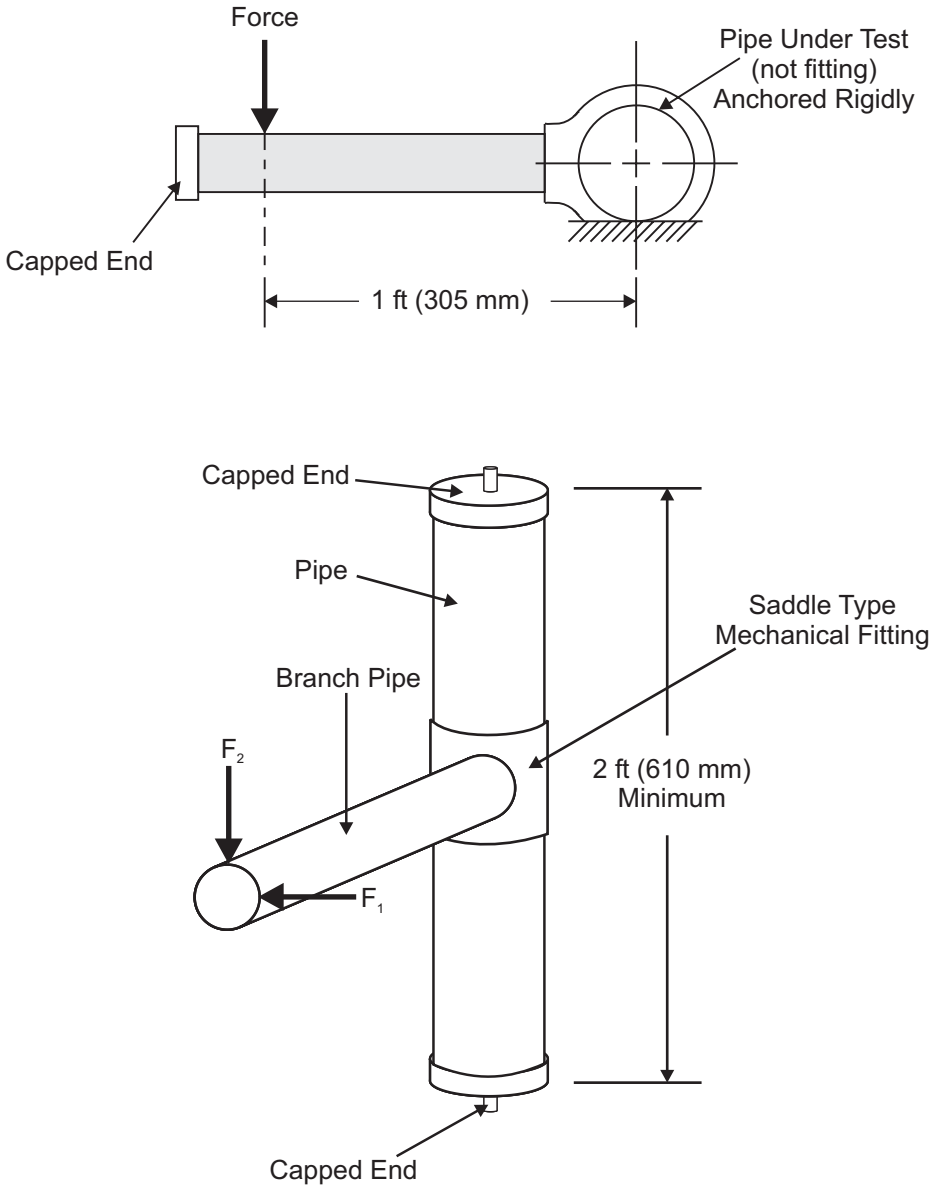
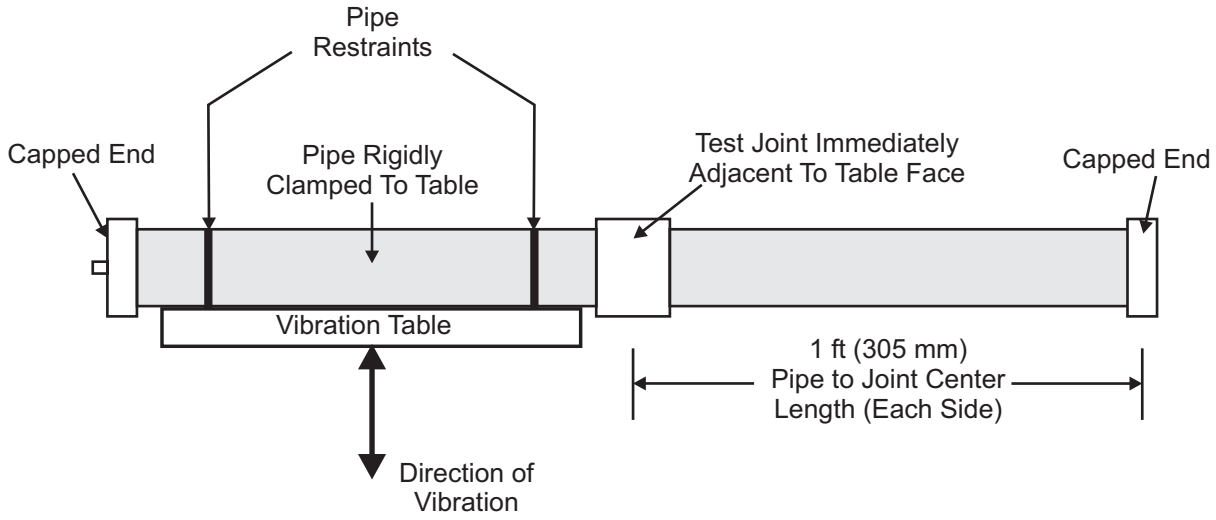


Figure C-2. Bending Moment



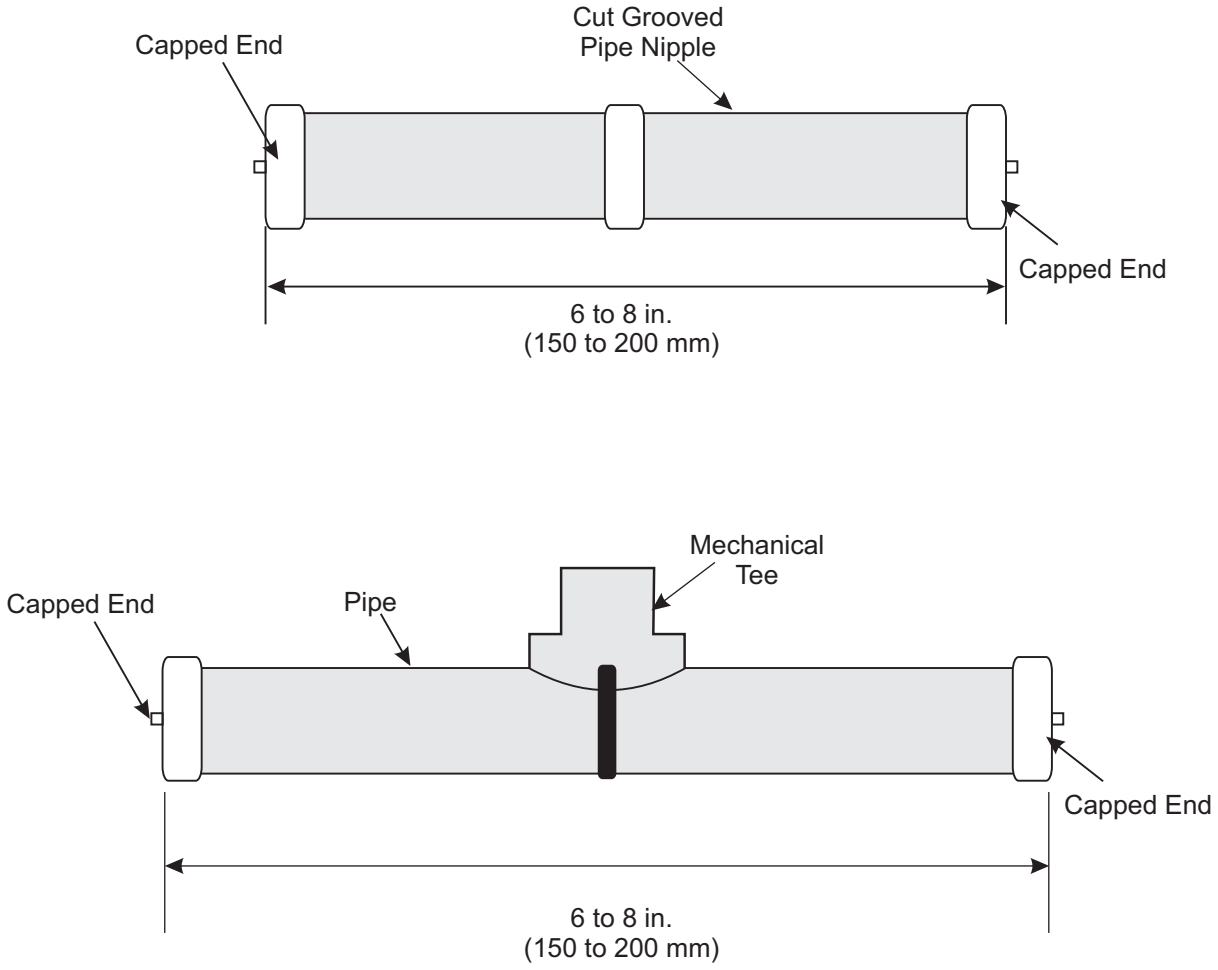
End caps should be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

Figure C-3. Rotational Bending Moment



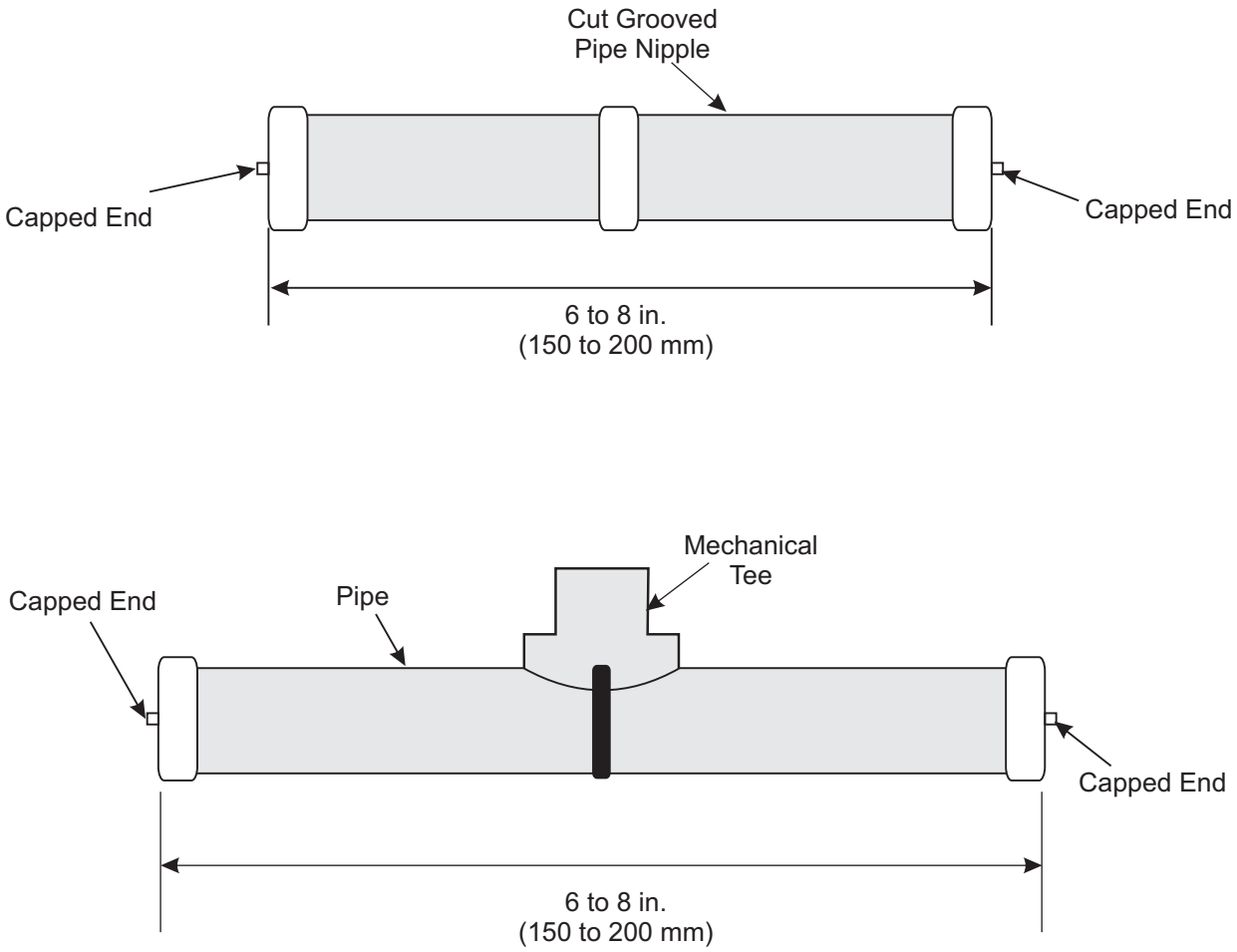
End caps should be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

Figure C-4. Vibration Test



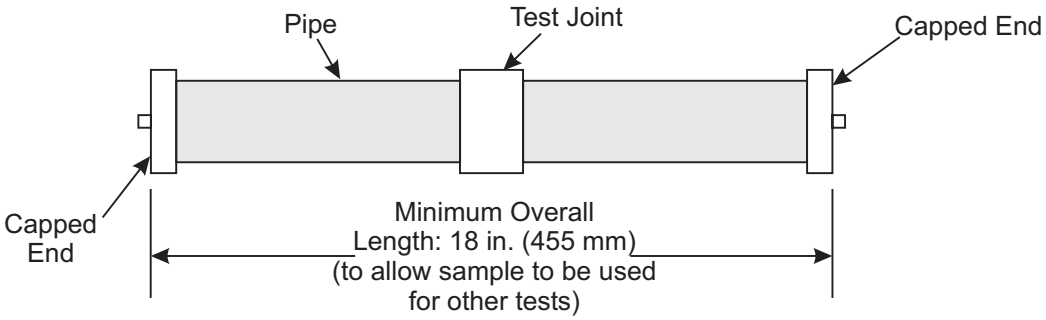
End caps should be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

Figure C-5. Vacuum Test

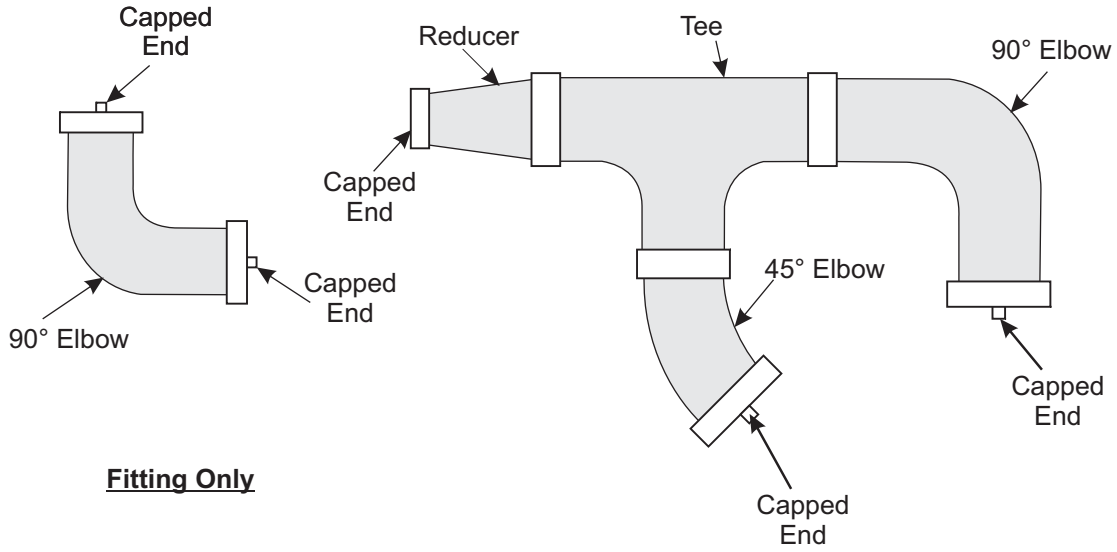


End caps should be drilled and tapped to 3/8 or 1/2 inch NPT in order to make use of standard connectors. Manufacturer to supply connectors if other than NPT.

Figure C-6. Hot Gasket / Cold Gasket Test



Pipe Only



Fitting Only

Assembly

End caps should 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-7. Cycling Pressure Test

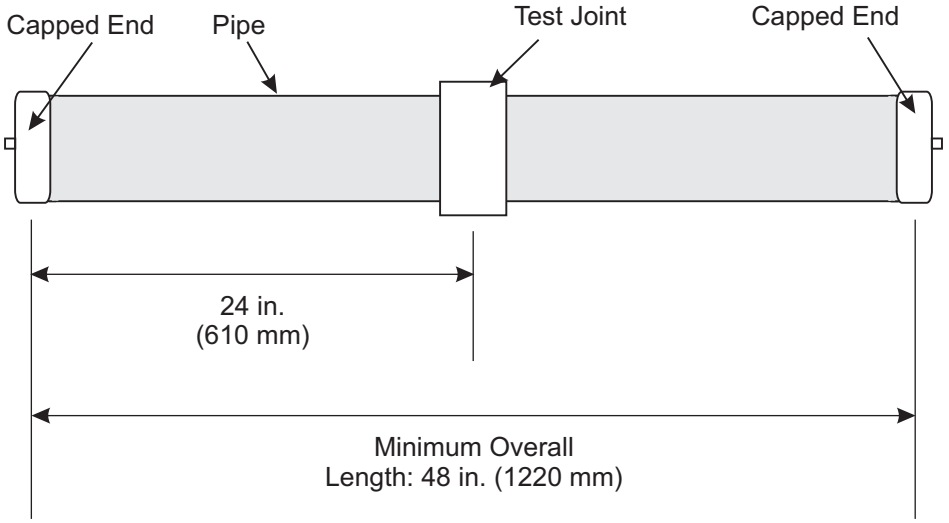
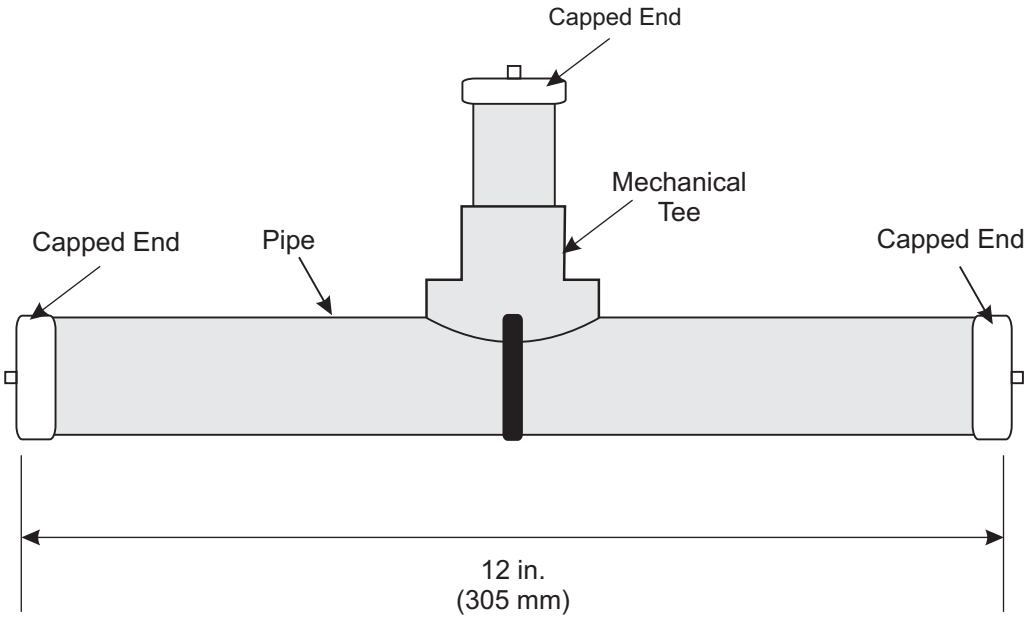


Figure C-8. Fire Test



End caps should 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-9. Friction Loss Test

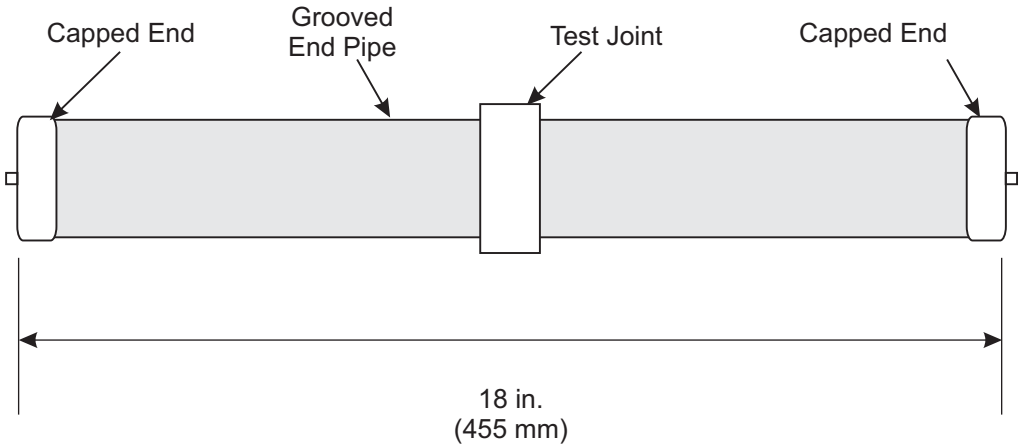
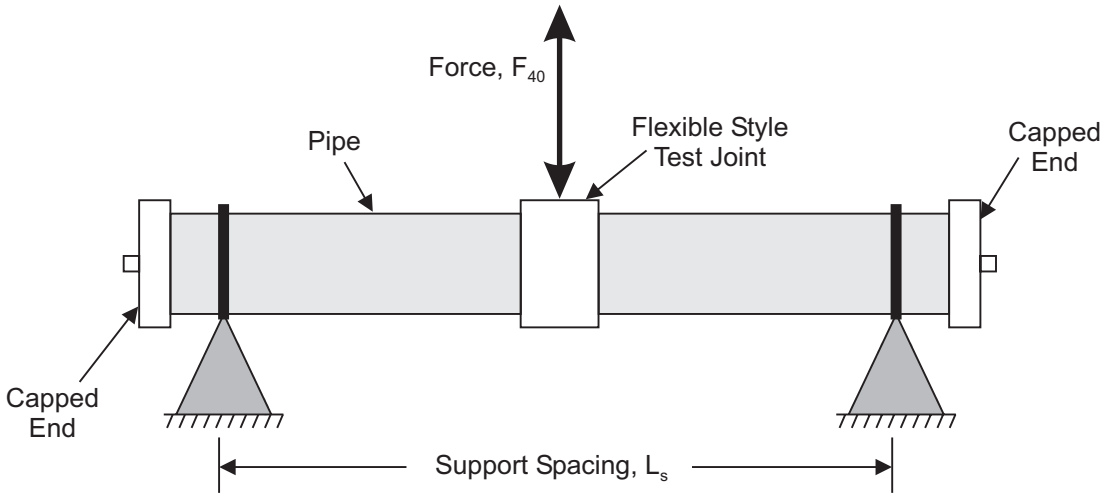


Figure C-10. Leakage Test



End caps should 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-11. Seismic Test

APPENDIX D: Bending Moment Calculations

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

Given: Hanger spacing, *LHS* = 15 ft (4.6 m) (maximum)
4 inch nominal pipe outside diameter, *OD* = 4.500 inches (115 mm)
Wall thickness (nominal), *T* = 0.237 inches (6 mm)
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 (1.0 g/cm^3)

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

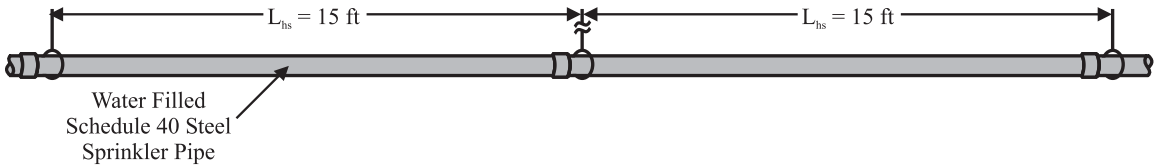


Figure D-1. Bending Moment Calculation

$$ID = OD - 2 \times T \qquad \textit{(Eq. 1)}$$
$$= 4.5\ in. - 2 \times (0.237\ in.) = 4.026\ in.$$

$$A_p = \frac{\pi\left(OD^2 - ID^2\right)}{4} \qquad \textit{(Eq. 2)}$$
$$= \frac{\pi\left[(4.5\ in.)^2 - (4.026\ in.)^2\right]}{4} = 3.174\ in.^2$$

$$V_p = A_p \times L \qquad \textit{(Eq. 3)}$$
$$= 3.174\ in.^2 \times \frac{12\ in.}{1\ ft} = 38.09\ \frac{in.^3}{ft}$$

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

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

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

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

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

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

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

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

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

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

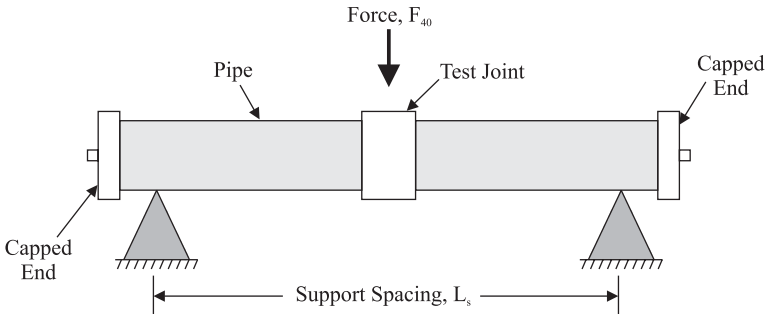


Figure D-2. Bending Moment Resistance Test

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

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

if $L_s = 4$ then $F_{40} = M$

if $L_s = 3$ then $F_{40} = 1.33\ M$

if $L_s = 2$ then $F_{40} = 2\ M$

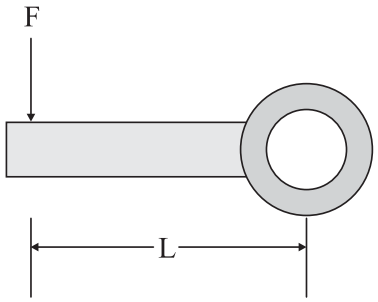


Figure D-3. Rotational Bending Moment Calculations

Maximum moment = FL

Maximum moment = the same as derived from grooved end couplings

Therefore, at a distance of L feet, F = M/L

APPENDIX E: Bending Moment Tables

Table E-1. *ASME B36.10M-2000, 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-2000, Copyright 2001 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.

Table E-2. *ASME B36.10M-2000, 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)
2-1/2	(65)	2.875	(73.0)	0.083	(2.1)	1135	(1540)	2270	(10 095)	1515	(6740)	1135	(5050)
3	(80)	3.500	(88.9)	0.083	(2.1)	1555	(2110)	3110	(13 835)	2075	(9230)	1555	(6915)

Notes:

1. The values for the Nominal Dimensions were referenced from ASME B36.10M-2000, Copyright 2001 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-2000. However, the hanger spacings used in the calculations were revised to be 12 feet (3.6 m) for all sizes.

Table E-3. *EN 10255 - 2004, 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 European Standard EN 10255 - 2004
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.

Table E-4. *EN 10255 - 2004 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 EN 10255 - 2004
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 Approval tests for test assemblies utilizing Medium Steel pipe shall be performed to the test load values shown in the ASME B36.10M-2000, Schedule 40 table.

Table E-5. *JIS G3454-1988, 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 G3454-1988. 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 F: Rotational Bending Moment Tables

Table F-1: *ASME B36.10M-2000 (Schedules 40)*

Nominal Pipe Size		ASME B36.10M-2000 Schedule 40			
		Bending Moment		Load Required	
NPS	(DN)	lb-ft	(N-m)	Lb	(N)
1	(25)	295	(400)	295	(1310)
1-1/4	(32)	420	(570)	420	(1870)
1-1/2	(40)	810	(1100)	810	(3605)
2	(50)	1150	(1560)	1150	(5115)
2-1/2	(65)	1770	(2400)	1770	(7875)
3	(80)	2425	(3290)	2425	(10 785)
3-1/2	(90)	3015	(4090)	3015	(13 410)
4	(100)	3670	(4975)	3670	(16 325)

Table F-2: *ASME B36.10M-2000 (Schedules 5)*

Nominal Pipe Size		ASME B36.10M-2000 Schedule 5			
		Bending Moment		Load Required	
NPS	(DN)	lb-ft	(N-m)	lb	(N)
1	(25)	295	(400)	295	(1310)
1-1/4	(32)	420	(570)	420	(1870)
1-1/2	(40)	520	(705)	520	(2315)
2	(50)	735	(995)	735	(3270)
2-1/2	(65)	1135	(1540)	1135	(5050)
3	(80)	1555	(2110)	1555	(6915)
3-1/2	(90)	-	-	-	-
4	(100)	-	-	-	-

Table F-3: *EN 10255 - 2004, (Medium and Heavy) and JIS G3454-1988 (Schedule 40)*

Nominal Pipe Size		EN 10255 - 2004 Medium				EN 10255 - 2004 Heavy				JIS G3454-1988 Schedule 40			
		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 Approval, if applicable, otherwise Schedule 10 will utilized.
6. The Schedules 10 and 30 rotational bending moment values are shown for reference only. Approval testing for these Schedules will be performed using the Schedule 40 values.

APPENDIX G: Sample Listings

Grooved Couplings, Grooved Reducing Couplings, Side Outlet Couplings and Fittings, Grooved Split Flanges:

Pipe Description	Model ABC Coupling, inch (mm)								
	1 (33.4)	1-1/4 (42.7)	1-1/2 (48.3)	2 (60.3)	2-1/2 (73.1)	(76.1)	3 (88.9)	(108)	4 (114.1)
Schedule 40, Cut Groove	300 (2070)	300 (2070)	300 (2070)	300 (2070)	300 (2070)		300 (2070)		300 (2070)
Schedule 40, Rolled Groove			300 (2070)	300 (2070)	300 (2070)		300 (2070)		300 (2070)
Schedule 10, Rolled Groove			300 (2070)	300 (2070)	300 (2070)		300 (2070)		300 (2070)
ThinWall Pipes									
Company A									
Company B									
Company C									
Lightwall Pipes									
Company A									
Company B									
Company C									
Schedule 5									
Company A									
Company B									
Company C									

Pipe Description	Model ABC Coupling, inch (mm)								
	(133)	(139.7)	5 (141.3)	(159)	(165.1)	6 (168.3)	8 (219.1)	10 (273)	12 (323.9)
Schedule 40, Cut Groove			300 (2070)			300 (2070)	300 (2070)	250 (1725)	250 (1725)
Schedule 40, Rolled Groove						300 (2070)	250 (1725)	175 (1205)	
Schedule 10, Rolled Groove						300 (2070)			
ThinWall Pipes									
Company A									
Company B									
Company C									
Lightwall Pipes									
Company A									
Company B									
Company C									
Schedule 5									
Company A									
Company B									
Company C									

Remarks:

a. Minimum schedule cut groove pipe to be joined: 6 inch or smaller, Schedule 40; 8 inch or larger, Schedule 30

b. Minimum schedule rolled groove pipe to be joined: 6 in or smaller, Schedule 10; 8 inch or 10 inch, 0.188 inch (5 mm) wall.

c. All couplings in table above, Approved when supplied with standard EPDM gasket (Green Stripe).

All Other Pipe Fittings:

Product Designation	*Nominal Pipe Size*	*Fitting Description*	*Remarks*	*Max. Rated Pressure, psi (kPa)*
ABC	1/2, 3/4, 1, 1-1/4	90° Elbow, threaded	a	300 (2070)
XYZ	2, 3, 4	Equal Tee, Grooved		175 (1205)
LMN	½ x 2, 2-1/2	Welded Branch Outlet, Threaded	a, b	300 (2070)

Remarks:
a. FM Approved when supplied with ANSI B1.20.1, NPT threads
b. Outlet connection achieved by welding fitting to pipe. Requires precutting of hole in pipe.

APPENDIX H: Tolerance

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 percent of value - 0 percent of value
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).

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