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NATIONAL STANDARD

ANSI/CAN/UL/ULC 1369:2020

STANDARD FOR SAFETY

Aboveground Piping for Flammable and Combustible Liquids

Approved American National Standard
ANSI
ANSI/UL 1369-2020

Standards Council of Canada
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UL Standard for Safety for Aboveground Piping for Flammable and Combustible Liquids, ANSI/CAN/UL/ULC 1369

First Edition, Dated August 31, 2018

Summary of Topics

This revision of UL/ULC 1369 dated August 25, 2020 is issued to reflect the current ANSI and SCC approval dates, and to incorporate the proposal dated June 12, 2020 which includes revisions to the Fire Test; 12.1, 12.1.1, 12.1.2, 12.4, 12.5, 14.1, and 15.1.

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated June 12, 2020.

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AUGUST 31, 2018
(Title Page Reprinted: August 25, 2020)

ANSI/UL 1369-2020

ANSI/CAN/UL/ULC 1369:2020

Standard for Aboveground Piping for Flammable and Combustible Liquids

First Edition

August 31, 2018

This ANSI/UL Standard for Safety consists of the First Edition including revisions through August 25, 2020.

The most recent designation of ANSI/UL 1369 as an American National Standard (ANSI) occurred on August 25, 2020. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page, Preface or SCC Foreword.

This standard has been designated as a National Standard of Canada (NSC) on August 25, 2020.

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Preface

This is the First Edition of the ANSI/CAN/UL/ULC 1369, Standard for Aboveground Piping for Flammable and Combustible Liquids.

UL is accredited by the American National Standards Institute (ANSI) and the Standards Council of Canada (SCC) as a Standards Development Organization (SDO).

This Standard has been developed in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization.

Appendix A, identified as Normative, forms a mandatory part of this Standard. Appendix B, identified as Informative, is for information purposes only.

This ANSI/CAN/UL/ULC 1369 Standard is under continuous maintenance, whereby each revision is approved in compliance with the requirements of ANSI and SCC for accreditation of a Standards Development Organization. In the event that no revisions are issued for a period of four years from the date of publication, action to revise, reaffirm, or withdraw the standard shall be initiated.

In Canada, there are two official languages, English and French. All safety warnings must be in French and English. Attention is drawn to the possibility that some Canadian authorities may require additional markings and/or installation instructions to be in both official languages.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at http://csds.ul.com.

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This Edition of the Standard has been formally approved by the Joint UL/ULC Technical Committee (TC) on Aboveground Piping for Flammable and Combustible Liquids.

This list represents the TC 1369 membership when the final text in this standard was balloted. Since that time, changes in the membership may have occurred.

TC 1369 Membership

Name	Representing	Interest Category	Region
Barker, A.	Technical Standards & Safety Authority	AHJ	Canada
Boyd, D.	BP America Inc	Commercial / Industrial User	USA
Crellin, K.	Brugg Pipe Systems North America (BPNA)	Non-voting member	USA
Fisher, L.	State Water Resources Control Board – Sacramento	AHJ	USA

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TC 1369 Membership Continued

Name	Representing	Interest Category	Region
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Murck, J.	Core Engineered Solutions, Inc	Supply Chain	USA
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Ticci, A.	Franklin Fueling Systems Ltd	Producer	UK
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International Classification for Standards (ICS): 75.160.20, 75.200

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This Standard is intended to be used for conformity assessment.

The intended primary application of this standard is stated in its scope. It is important to note that it remains the responsibility of the user of the standard to judge its suitability for this particular application.

CETTE NORME NATIONALE DU CANADA EST DISPONIBLE EN VERSIONS FRANÇAISE ET ANGLAISE

INTRODUCTION

1 Scope

1.1 These requirements cover primary, secondary, and coaxial types of aboveground pipes intended for transfer and containment of specific flammable and combustible liquids and fuels or fuel components (and vapors thereof) identified in this Standard, at their manufacturing, processing and distribution facilities, commercial (public) or fleet (private) motor vehicle fueling stations or similar fuel dispensing applications, and piping systems for fuel supply of generators, burners or similar equipment.

1.2 These pipes may be flexible or rigid types constructed with metallic, nonmetallic, or composite materials in single continuous or multiple joined lengths with integral end fittings in nominal sizes from 12.7 mm to 152.4 mm (0.5 in to 6.0 in) diameters, and are typically intended for use in the following applications:

a) General aboveground use either directly on or suspended above the ground, such as piping between tanks and dispensers or within buildings, such as fuel supply lines to rooftop generators or basement boilers, which may include short lengths routed in below grade containment sumps and underground chase pipe where accessible, but not where directly buried; or

b) Special aboveground uses that requires an additional evaluation for a specific purpose, such as marinas, and where specific liquids or extreme environments are not represented by the general test liquids and expected exposures conditions.

1.3 These pipes are intended for commercially available fuels and fuel components, and similar flammable and combustible liquids under the expected use conditions, and exposures that have similar chemical, physical and material compatibility properties as represented in these requirements.

1.4 Products covered by this Standard are intended to be installed and used in accordance with the applicable Codes and Regulations as determined by the Authority Having Jurisdiction (AHJ), such as, but not limited to:

In the United States:

a) Standard for the Installation of Stationary Pumps for Fire Protection, NFPA 20;

b) Flammable and Combustible Liquids Code, NFPA 30;

c) Code for Motor Fuel Dispensing Facilities and Garages, NFPA 30A;

d) Standard for the Installation of Oil-Burning Equipment, NFPA 31;

e) Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA 37;

f) Standard for Aircraft Fuel Servicing, NFPA 407;

g) Uniform Fire Code, NFPA 1;

h) International Fire Code published by the International Fire Council; and/or

i) Other applicable federal and state regulations for piping.

In Canada:

a) The National Fire Code of Canada;

b) CAN/CSA-B139, Installation Code for Oil Burning Equipment;

c) CCME PN 1326, Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products; and/or

d) Provincial or other Regulations.

1.5 The following Recommended Practices may be used as determined by the Authority Having Jurisdiction (AHJ):

a) Recommended Practices for Installation of Aboveground Storage Systems for Motor Vehicle Fueling, PEI/RP 200;

b) Recommended Practices for Installation of Bulk Storage Plants, PEI/RP 800;

c) Recommended Practices for the Installation of Marina Fueling Systems (2014 Edition), PEI/RP 1000;

d) Recommended Practices for the Design, Installation, Service, Repair and Maintenance of Aviation Fueling Systems (2013 Edition), PEI/RP 1300;

e) Recommended Practices For The Design And Installation Of Fueling Systems For Emergency Generators, Stationary Diesel Engines And Oil Burner Systems (2014 Edition), PEI/RP 1400.

1.6 These products are factory manufactured and intended for on-site field assembly, inspection, and leak testing for the specified applications and use conditions by qualified persons in accordance with the manufacturer's instructions and local requirements.

1.7 These products are intended to be periodically inspected and maintained for continued service, or taken out of service if necessary, by qualified persons in accordance with industry recommended practices and/or the manufacturer’s instructions.

1.8 These products have not been evaluated for use after natural disasters, fires or exposures to chemicals not representative of the test liquids, or excessive physical damage beyond the expected assembly, installation and uses as identified in these requirements.

1.9 These products have not been evaluated for applications where exposed to heavy or continuous physical abuses, excessive mechanical stresses; and environments that are highly corrosive; or operate outside of the expected ambient use temperature range for significant times.

1.10 These requirements do not cover aboveground piping products for liquid fuels, which are within the scope of UL 180, Liquid-Level Gauges for Oil Burner Fuels and Other Combustible Liquids and ULC/ORD-C180, Liquid Level Gauges And Indicators For Fuel Oil And Lubricating Oil Tanks; or underground piping products which are found in CAN/ULC-S679, Standard for Metallic and Nonmetallic Underground Piping for Flammable and Combustible Liquids; UL 971, Standard for Nonmetallic Underground Piping For Flammable Liquids; and UL 971A, Outline of Investigation for Metallic Underground Fuel Pipe.

1.11 These requirements do not cover aboveground piping products for gaseous fuels (such as natural gas, liquefied petroleum gas, propane, butane, etc.), which are found in UL 536, Standard for Flexible Metallic Hose; and ULC/ORD-C536, Flexible Metallic Hose.

1.12 These requirements do not cover flexible metal connector piping or flexible elastomeric fuel dispensing and vapor recovery hose, which are found in UL 2039, Standard for Flexible Connector Piping for Fuels; UL 330A, Outline of Investigation for Hose and Hose Assemblies for Use With Dispensing Devices Dispensing Gasoline and Gasoline/Ethanol Blends With Nominal Ethanol Concentrations Up To 85 Percent (E0 – E85); UL 330B, Standard for Hose and Hose Assemblies for Use With Dispensing

Devices Dispensing Diesel Fuel, Biodiesel Fuel, Diesel/Biodiesel Blends With Nominal Biodiesel Concentrations Up To 20 Percent (B20), Kerosene, and Fuel Oil; and CAN/ULC-S633, Standard for Flexible Connector Piping for Fuels.

2 General

2.1 Units of measurement

2.1.1 Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Undated references

2.2.1 Any undated reference to a code or standard appearing in the requirements of this standard shall be interpreted as referring to the latest edition of that code or standard. Refer to Appendix B for a list of referenced publications and publishing organizations.

3 Glossary

NOTE: For the purposes of this Standard the following definitions apply.

3.1 COMPOSITE PIPE SYSTEM – A piping system in which the pipe design contains both metallic and nonmetallic major, critical components.

3.2 FITTING – A manufacturer-supplied component designed to connect, branch, or terminate pipe sections and contain liquids. Connections may be threaded, welded, crimped, clamped, compressed, thermo fused, solvent welded, or adhesive joined. Sump boots are not considered fittings.

3.3 FLEXIBLE PIPING – Pipe which is permitted to be bent to the manufacturer's recommended minimum bend radius.

3.4 INTEGRAL – Two or more separate components physically joined together or combined to form a single part at the manufacturer. Primary and secondary pipe joined in the field with a common fitting is not considered integral.

3.5 INTEGRAL PRIMARY/SECONDARY PIPE (aka COAXIAL PIPE) – A single pipe, constructed at the manufacturer, that combines both primary carrier and secondary containment with an interstitial space that can be monitored for leakage.

3.6 METALLIC – Pipe, fittings, or components primarily consisting of metals (typically corrosion- resistant malleable types such as steel, aluminum, copper, and brass) with or without minor nonmetallic components (such as gaskets, seals, sleeves or bushings).

3.7 METALLIC PIPE SYSTEM – An aboveground piping system in which the pipe design contains major critical components that are formed from metals.

3.8 NON-INTEGRAL PRIMARY/SECONDARY PIPE – A pipe system with independent primary carrier and secondary containment connected in the field with an interstitial space that can be monitored for leakage.

3.9 NONMETALLIC – Pipe, fittings, or components primarily consisting of nonmetals (typically polymeric thermoplastics, thermosets or composites) with or without minor metallic components (such as foils, braids, tapes, sleeves, or bushings).

3.10 NONMETALLIC PIPE SYSTEM – A piping system in which the pipe design contains major critical components that are not formed from metals.

3.11 PIPE – A long cylindrical thin-walled structure designed for the intended use of conveying or containing liquids. The pipe structure may be formed from homogenous elements (single material), composite elements (multiple materials mixed together) or integral elements (individual materials joined as one component).

3.12 PIPE OR FITTING SIZE – Nominal or trade size (inches or mm) based on inside diameters of pipe and fittings.

NOTE: Nominal or trade sizes may not be equivalent to the actual measurements.

3.13 PIPING SYSTEM (aka SYSTEM) – A combination of pipes and fittings joined to contain liquids transferred between a storage tank and sumps or dispensers (primary, secondary, or integral primary/secondary types) and vapor or air transfer between dispenser or tank to atmosphere (normal vent and vapor recovery types). The system may be primary, secondary, or an integral primary/secondary type.

3.14 PRIMARY PIPE (aka CARRIER PIPE, PRODUCT PIPE) – Pipe intended to be in continuous contact with the liquid and vapor flowing in a piping system under normal use.

3.15 QUALIFIED PERSON – A worker specifically trained by the manufacturer to perform proper installations of its piping systems in the field in accordance with the specified instructions. The qualified person is not required to be an employee of the manufacturer.

3.16 RIGID PIPING – Pipe which is not permitted to be bent, as described by the manufacturer's instructions.

3.17 SECONDARY CONTAINMENT PIPE – Pipe intended to contain the release of liquid of a piping system during abnormal use (for example, primary carrier pipe leaks).

CONSTRUCTION

4 General

4.1 Aboveground pipes are permitted to be either flexible or rigid and constructed from any combination of materials, but shall be capable of field assembly and installation without the use of special equipment or tools, unless identified in the manufacturer's instructions.

4.2 Individual manufactured pipe lengths (pipe and fittings) shall not be less than 1.83 m (6 ft). The diameter of aboveground piping shall be in a nominal trade sizes range of 12.7 to 152.4 mm (0.5 to 6.0 in).

4.3 Primary pipe and the primary of a coaxial pipe shall be rated at least 345 kPa (50 psig). Secondary pipe and the secondary of a coaxial pipe shall be rated at least 345 kPa (50 psig).

4.4 Aboveground piping shall be supplied with end fittings that are capable of connection to each other or assembled to fixed pipe or fueling components, such as threaded fittings, or bolted flanges, clamp type flanges, or weld/bond joints. All pipe threads shall be NPT, NPTF, BSPT, BSPP or similar common trade types. All bolts, gaskets, and other components for assembly and installation of the pipe ends shall be supplied with the product.

4.5 All materials used in the construction of pipe and fittings shall be suitable for their intended use locations with respect to normal (expected use within marked ratings) and abnormal (reasonable

foreseeable misuse) or optional special conditions in accordance with the required performance tests described in this standard.

4.6 Nonmetallics (polymers, elastomers, ceramics, etc.) used in the construction of pipe and fittings shall be evaluated for long-term exposure compatibility to air, soil, water, ultraviolet light, and internal and external fluids within the expected ambient use temperature range for aboveground use per the scope of this standard.

4.7 Metallics used in the construction of pipe and fittings shall be inherently corrosion resistant (such as stainless steel, aluminum, brass), plated, or coated according to Clause 4.8, or evaluated for equivalent corrosion resistance according to Clause 4.9. All metals shall comply with all applicable requirements in this standard.

4.8 Corrosion resistant coatings or platings provided on metals (such as plain carbon steel) shall be minimum designation G90 (minimum 40 % zinc galvanizing on all sides) per ASTM A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy- Coated (Galvannealed) by the Hot-Dip Process.

4.9 Equivalent alternate corrosion protection methods shall be determined by an evaluation of coating or plating in accordance with the method in the Standard for Electrical Metallic Tubing, UL 797, except with the visual corrosion comparison between benchmark G90 and alternate protection conducted after exposures to Table 11.1 Compatibility Test Liquids.

4.10 Protective packaging or other devices that provide short term resistance for protection of pipe or fittings during transport are permitted if weather resistant, but shall remain in place until installation and shall be evaluated for short term physical damage (as indicated in the applicable requirements for Short Term Compatibility and Physical Abuse Tests in this standard).

PERFORMANCE

5 General

5.1 Representative production samples of each aboveground pipe type or component shall be subjected to the appropriate Performance Tests in Table 5.1 with sample variations of pipe type, design material, and size as specified in each test method. Special samples combining different variations, such as end fitting, joint and gasket options, in order to reduce the total number of samples are permitted, provided they are representative of regular design, material and production methods.

Table 5.1
Aboveground pipe test summary

Test (Section)	General use pipe	Marine use pipe
Pressure Tests (6)	All Worst Case (WC) Primary, Secondary & Coaxial Pipes @	
General (6.1)	Low (-30 °C or -40°C), High (+50°C or +60°C) & Lab Temp (22+/-4°C)	
Leakage (6.2)	2 X Rated – No Leakage or Distortion	
Hydrostatic (6.3)	5 X Rated – No Leakage	
Breakdown (6.4)	Until Breakdown	
Mechanical Tests (7)	WC Types as specified:	
Interstitial communication (7.1)	Secondary or Coaxial Only[1] – Communication Rate > 63 cm/h	

Table 5.1 Continued on Next Page

Table 5.1 Continued

Test (Section)	General use pipe	Marine use pipe
Design pressure (7.2)	Nonmetallic Primary and Primary of Coaxial	
Sustained pressure (7.2.2)	Flexible (thermoplastic types) per ASTM D2837	
Cyclic pressure (7.2.3)	Rigid (thermoset types) Per ASTM D2143	
Design vacuum (7.3)	Primary and the Primary of Coaxial	
Static vacuum (7.3.2)	10 min @ 63.5 cm Hg	
Cyclic vacuum (7.3.3)	250k cycles @ 0 psi to rated vac	
Physical Abuse Tests (8)	All WC Primary, Secondary and Coaxial Pipes @ high and low temps[2]	
General (8.1)	Repeat Leakage and Breakdown after each test or sequence of tests	
Drop (8.2)	1.83 m drop on concrete	
Impact (8.3)	13.6 J impact @ 3 locations	
Puncture (8.4)	13.6 kg point load for 1 hr	
Fitting torque (8.5)	1.5X torque rating	
Pipe torque (8.6)	90° twist for 1 hr	
Tension (8.7)	Pull per Table 8.1 loads for 1 min	
Compression (8.8)	Crush with 7.6 cm metal plate @ 2224 N for 1 min	
Bending (8.8)	Bend @ 1.5 X min rating or deflection of longest filled pipe between supports	
Support bracket (8.10)	2 X load of filled pipe @ max length between supports for 1 min	
Special Use Rating Options (9)	Any WC Pipe with Optional Special Use Ratings	
General (9.1)	Marina Pipe Tests for fixed piers and semi-fixed or floating docks	
Corrosion resistance (9.1)	400 h salt fog per ASTM B117 & 1200 h CO_2/SO_2 atmosphere	
Tide cycle (9.3)	10k cycles dynamic bending @ 10 deg > min bend radius	
Short Term Compatibility Tests (10)	WC Types as specified:	
UV exposure (10.2)	Exposed exterior polymers – ASTM G153 or G155 for indoor or outdoor use	
Metallic stress crack (10.3)	Metals w > 15% Zn – 0.94 spg aqueous ammonia exposure @ 34°C for 10 d	
Nonmetallic stress crack (10.4)	PE– 10 % poly-oxyethylated nonylphenol exposure @ 60°C for 180 hr	
Long Term Compatibility Tests (11)	Accelerated aging exposures to Table 11.1 Fuels and Fluids @ elevated temps for 180/270 d w min 70/50% Physical Property Retention and Repeat Tension, Compression followed by Repeat Leakage and Breakdown	
Fire Test (12)	Min 30 min (or optional longer time) kerosene fire exposure @ rated pressure	

[1] Exception for a continuous interstitial space ≥ 2.5 mm between primary and secondary pipe walls.

[2] Exception for designs with exterior metal walls or metal fittings need only be tested at the low temperature.

5.2 Critical dimensions (such as diameter, thickness, corrugation, out of round, threads, braids, etc.) of 10 random samples of each pipe type, construction, and size, shall be measured before other tests are conducted. All sample dimensions shall be within the manufacturer's quality control specifications, and:

a) Thickness of each sample shall be within ± 15 % of the test set average; and

b) Diameters of each sample shall be within ± 10 % of the test set average.

5.3 The formula for calculated hoop stress, specified below, may be used to determine “worst case” sizes to reduce the number of specimens when testing homogeneous mono-layer pipe in all nominal sizes for a product range. In addition, analyzed data from the Section 6, Pressure Test sequence may be used to determine worst case samples for other specific tests.

$$S = P\,(D - t)\,/\,2t$$

in which:

S is hoop stress (psi);

P is the breakdown pressure (psi) according to Subsection 6.4, Breakdown Test;

D is the average outside diameter inches per Clause 5.2; and

t is the minimum wall thickness inches per Clause 5.2.

Exception: The above formula may be modified or another engineering-based analysis used for multilayer and non-homogeneous pipe to determine the worst case size in a product range.

5.4 Representative sample sizes for the Performance Tests are defined as either:

a) “ALL” for all nominal or trade sizes within a manufacturer's product range;

b) “WC” for worst case sizes per maximum average hoop stress per Clause 5.3, or other analytical method; or

c) As otherwise indicated in the specific test.

“WC” (worst case) indicates a sample, size, or test condition that will most likely cause non-compliance. Materials, thickness, construction, components, and connections are to be considered for worst case selections.

5.5 Representative worst case sample sizes for Section 11, Long Term Compatibility Tests, shall be based on the minimum thickness of interior or exterior materials in contact with the test fluids, and other critical design parameters such as end fitting, joint options, location ratings, pressure ratings and bend radius.

5.6 New samples may be used for each test except for the sequence of the Short Term Pressure Tests (Leakage according to Subsection 6.2, Hydrostatic according to Subsection 6.3 and Breakdown according to Subsection 6.4), which shall use the same sample and test equipment at successively higher pressures. If acceptable to the manufacturer, the same sample may be used for multiple tests.

5.7 Assembly of all piping samples shall be conducted by a qualified person using manufacturer-supplied components in accordance with the manufacturer's instructions (thread torque, crimp pressure or other critical assembly parameters). If multiple methods of connecting pipe and fittings are used, each shall be evaluated.

5.8 Damage shall be determined by visual examination [from approximately 92 cm (3 ft)] of any critical sample or part after testing. The following items are examples of complying and noncomplying results; however, final determination of damage characteristics and results shall be based on manufacturer input before testing or qualified by a specific test:

a) Metallic Piping and Fittings – discoloration or minor dimensional change are compliant, but excessive permanent deformation, crazing, cracking, splitting, braid failure, kinking, and excessive corrosion or loss of corrosion protection are noncompliant examples; or

b) Nonmetallic Piping and Fittings – discoloration or minor dimensional change are compliant, but major dimensional changes, cracking, splitting, bulging, collapse, and delamination are noncompliant examples.

5.9 Unless otherwise indicated in a specific test method, all tests shall be conducted with working fluids at 21 ±6 °C (70 ±10 °F) or at normal ambient temperatures between 17 °C and 29 °C (65 °F and 85 °F) and 50 % (±20 %) RH. All pressures shall be measured with respect to gauge (psig).

5.10 Users of this standard who determine that the high and low temperature test values for severe service conditions stated in testing requirements are not adequate to meet the demands of their specific applications may apply higher/lower test temperatures and revise the product marking accordingly.

5.11 Unless otherwise indicated in a specific test method, hydrostatic tests shall be conducted with water and pneumatic tests shall be conducted with air (or other inert gasses). In either case, precautions shall be used to prevent personal injury.

6 Pressure Tests

6.1 General

6.1.1 Sets of three 92 cm (3 ft) lengths of each type, construction, and size pipe shall be tested in a continuous sequence on the same sample, in accordance with the:

a) Leakage Test per Subsection 6.2;

b) Hydrostatic Test per Subsection 6.3; and

c) Breakdown Test per Subsection 6.4.

6.1.2 All aboveground pipes evaluated are to be filled with water (with or without antifreeze as required) before applying the test pressures hydrostatically. The test sequence shall start at 0 kPa (0 psig) and gradually increase:

a) At 69 ±35 kPa/min (10 ±5 psig/min) for pipe rated less than 345 kPa (50 psig); or

b) At 690 ±138 kPa/min (100 ±20 psig/min) for pipe rated 345 kPa (50 psig) or more.

6.1.3 There shall be at least a 5 min pause at each test level (except for the Breakdown Test, Subsection 6.4) when the samples are to be visually examined for damage and leakage. Filling and sealing the primary of a coaxial pipe is permitted when testing the secondary to prevent implosion.

6.1.4 All samples used for the Pressure Tests shall be tested hydrostatically. Alternatively, an aerostatic method or combined hydrostatic/aerostatic method may be used if found superior to the hydrostatic method to accurately determine leakage. Leakage is to be detected by visual examination with the aid of dyes, leak solution, blotting paper, bubble submersion, or any other accurate and repeatable method.

6.2 Leakage test

6.2.1 Aboveground pipe of all types, constructions, and sizes shall be subjected to the Leakage test while at the following test temperatures for at least 1 h:

a) Low temperature of -30 °C (-22 °F) or -40 °C (-40 °F) for an optional “Severe LT” (Severe Low Temperature) rating. Refer to Clause 5.10;

b) Laboratory temperature range of 22 ±4 °C (72 ±7 °F); and

c) High temperature of 50 °C (122 °F) or 60 °C (140 °F) for an optional “Severe HT” (Severe High Temperature) rating. Refer to Clause 5.10.

6.2.2 The Leakage Test pressure shall be at least twice the rated pressure, and there shall be no leakage or any noncomplying damage (see Clause 5.8) while the samples are pressurized.

6.3 Hydrostatic test

6.3.1 Following the Leakage test, aboveground pipe of all types, constructions and sizes shall be subjected to the Hydrostatic test while at the following test temperatures for at least 1 h:

a) Low temperature of -30 °C (-22 °F) or -40 °C (-40 °F) for an optional “Severe LT” rating. Refer to Clause 5.10;

b) Laboratory temperature range of 22 ±4 °C (72 ±7 °F); and

c) High temperature of 50 °C (122 °F) or 60 °C (140 °F) for an optional “Severe HT” rating. Refer to Clause 5.10.

6.3.2 The hydrostatic test pressure shall be at least five times the rating. There shall be no leakage (but damage is acceptable) while the samples are pressurized.

6.4 Breakdown test

6.4.1 Following the Hydrostatic test, aboveground pipe of all types, constructions and sizes shall be subjected to the Breakdown test while at the following test temperatures for at least 1 h:

a) Low temperature of -30 °C (-22 °F) or -40 °C (-40 °F) for an optional “Severe LT” rating. Refer to Clause 5.10;

b) Laboratory temperature range of 22 ±4 °C (72 ±7 °F); and

c) High temperature of 50 °C (122 °F) or 60 °C (140 °F) for an optional “Severe HT” rating. Refer to Clause 5.10.

6.4.2 The test pressure is to be gradually increased at the rates specified in Clause 6.1.2 until severe leakage, rupture or burst occurs. The type and location of breakdown or other significant damage shall be recorded along with the breakdown pressure for use in comparing with retention values in this and other tests.

6.4.3 The average breakdown values for high temperature and low temperature sample sets shall not be less than 5 times the rated pressure, or 70 % of the average laboratory temperature sample set. The average breakdown value of each temperature set shall not deviate more than ±20 % from the average of all three temperature sets.

7 Mechanical Tests

7.1 Interstitial communication test

7.1.1 A minimum 1.83 m (6 ft) length of the pipe types below in worst case sizes and fittings with respect to minimum interstitial space, shall be subjected to the test described in Clause 7.1.2 to measure the communication rate. A 90° elbow on one end shall be used to add the test liquid. Separate tests shall be conducted on:

a) Field-use combinations of primary and secondary pipe; and

b) Coaxial pipes.

Exception: Pipes with a continuous interstitial space of at least 2.5 mm (0.10 in) between primary and secondary pipe walls and fittings are exempt.

7.1.2 The sample on a flat surface shall be bent to the minimum rated radius, with water added to the interstitial space at the elbow with a hydrostatic head not exceeding 15 cm (6 in). The time between introduction and exit of the test liquid at opposite ends of the pipe shall be measured.

7.1.3 The calculated communication rate (distance/time) shall not be less than 63 cm/h (2 ft/h).

7.2 Design pressure tests

7.2.1 General

7.2.1.1 Three 92 cm (3 ft) lengths of nonmetallic primary pipe types and systems indicated in each test method in all sizes shall be tested in accordance with the Subsection 7.2.2 Sustained Pressure Test, or the Subsection 7.2.3 Cyclic Pressure Test, as determined by the pipe type or majority of structural pipe materials.

7.2.1.2 Worst case samples used for the Long Term Pressure Tests shall use water as the test fluid. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion or any other accurate and repeatable method.

7.2.1.3 Composite pipe of shared structural strength (where at least 80 % of the hoop strength cannot be attributed to either metallic or nonmetallic components) is permitted to be evaluated in accordance with either the Subsection 7.2.2 Sustained Pressure Test, or Subsection 7.2.3 Cyclic Pressure test.

7.2.2 Sustained pressure test

7.2.2.1 Only flexible thermoplastic type primary pipe and the primary of coaxial pipe systems shall be subjected to the Sustained Pressure Test. Alternatively, pipe constructed primarily from nonmetallics, or composite pipe where at least 80 % of hoop strength is attributed to nonmetallics, shall be subjected to this test.

7.2.2.2 Three samples of each system shall be tested in accordance with ASTM D 2837, Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products, with the breakdown time and pressures recorded at targeted times of approximately 1, 10, 100, 1000, and 2000 h.

7.2.2.3 Following the collection of all data points, a log and log plot of time verses pressure shall be developed, and a 30-year breakdown pressure extrapolated. The rated pressure shall be greater than the extrapolated 30-year breakdown pressure.

7.2.3 Cyclic pressure test

7.2.3.1 Only rigid thermoset type primary pipe and the primary of coaxial pipe systems shall be subjected to the Cyclic Pressure Test. Alternatively, pipe constructed primarily from metals or composite pipe where at least 80 % of hoop strength is attributed to metals shall be subjected to this test.

7.2.3.2 Three samples of each system shall be tested in accordance with ASTM D 2143, Test Method for Cyclic Pressure Strength of Reinforced Thermosetting Plastic Pipe. Alternating pressures (between 0 and rated pressure of equal times) shall be applied at 25 ±2 cycle/min for 1.5 million cycles.

7.2.3.3 Following the completion of the cycling, the test samples shall be visually examined for damage and leakage. There shall be no leakage or any noncomplying damage during or after testing.

7.3 Design vacuum tests

7.3.1 General

7.3.1.1 Sets of three 92 cm (3 ft) lengths of each aboveground primary or the primary of a coaxial pipe system type and construction in worst case sizes specified in each method shall be tested in accordance with the Subsection 7.3.2 Static Vacuum Test and the Subsection 7.3.3 Cyclic Vacuum Test.

7.3.1.2 Vacuum Tests shall use air as the test fluid, and unless otherwise specified, the leakage test shall be conducted using water as the test fluid. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion or any other accurate and repeatable method.

7.3.2 Static vacuum test

7.3.2.1 Each type and construction of primary pipe in worst case sizes shall be subjected to the Static Vacuum Test while operating at a laboratory temperature of 22 ±4 °C (72 ±7 °F), except thermoplastics shall be tested at 50 °C (122 °F).

7.3.2.2 All samples shall be subjected to a static vacuum of at least 63.5 cm (25 in) Hg for 10 min followed by a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at laboratory temperature only.

7.3.2.3 The samples shall not be damaged after the static vacuum or leak after pressurizing. The average breakdown value for each sample set shall be at least 1724 kPa (250 psig) for primary pipes, and/or 1379 kPa (200 psig) for secondary pipes, with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

7.3.3 Cyclic vacuum test

7.3.3.1 Each type and construction of primary pipe in worst case sizes shall be subjected to the Cyclic Vacuum Test while operating at a laboratory temperature of 22 ±4 °C (72 ±7 °F).

7.3.3.2 All samples shall be subjected to alternating pressure cycles (minimum 1 s at 0 and minimum 5 s at rated vacuum) applied at 4 to 6 cycle/min for 250,000 cycles followed by a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at laboratory temperature only.

7.3.3.3 The samples shall not be damaged after cyclic vacuum or leak after pressurizing. The average breakdown value for each sample set shall be at least 1724 kPa (250 psig) for primary and/or 1379 kPa (200 psig) for secondary, with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8 Physical Abuse Tests

8.1 General

8.1.1 Sets of three samples of each worst case aboveground pipe type, construction, and size as indicated in each method shall be tested in accordance with the following:

a) Drop Test according to Subsection 8.2 for all pipes;

b) Impact Test according to Subsection 8.3 for all pipes;

c) Puncture Test according to Subsection 8.4 for all pipes;

d) Fitting Torque Test according to Subsection 8.5 for all pipes;

e) Pipe Torque Test according to Subsection 8.6 for all pipes;

f) Tension Test according to Subsection 8.7 for all pipes;

g) Compression Test according to Subsection 8.8 for all pipes;

h) Bending Test according to Subsection 8.9 for all pipes; and

i) Support Bracket Test according to Subsection 8.10 for all pipes intended to be suspended or mounted to ceilings or walls.

8.1.2 After each Physical Abuse Test, all samples shall be subjected to the Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4, at laboratory temperature only. Water shall be used as the test fluid to determine compliance. Leakage shall be detected by visual examination with or without dyes, leak solution, blotting paper, bubble submersion or any other accurate and repeatable method.

8.2 Drop test

8.2.1 One set of three 92 cm (3 ft) samples of each aboveground pipe in worst case sizes shall be subjected to 1.83 m (6 ft) drops at 50 °C (122 °F) and -30 °C (-22 °F), or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10), each followed by a visual examination. After drops at applicable temperatures, a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 shall be conducted at only laboratory temperature.

Exception: Pipe designs with exterior metal constructions need only be tested at the low temperature.

8.2.2 All samples shall be dropped on a flat concrete surface after reaching the specified temperatures, with the drop height measured from the sample target area. One sample shall be dropped three times per temperature, at target areas of the pipe center, end fitting, and pipe near the fitting respectively. Adjusting the pipe orientation to hit the targeted areas is permitted.

8.2.3 The samples shall not be damaged after dropping or leak after pressurizing. The average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.3 Impact test

8.3.1 One set of three 92 cm (3 ft) samples of each aboveground pipe in worst case sizes shall be subjected to 13.6 J (10 ft·lb) impacts at 50 °C (122 °F) and -30 °C (-22 °F), or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10) each followed by a visual examination. After impacts at applicable temperatures, a repeat Leakage Test according to Subsection 6.2 and the Breakdown Test according to Subsection 6.4 shall be conducted at only laboratory temperature.

Exception: Pipe designs with exterior metal constructions need only be tested at the low temperature.

8.3.2 All samples shall rest on a hard surface and be impacted with a 51 mm (2 in) OD steel ball after reaching the specified temperatures, with the impact height measured from sample target area. One

sample shall be impacted three times per temperature, at target areas of the pipe center, end fitting and pipe near the fitting respectively. Use of a ball guide to hit the target areas is permitted.

8.3.3 The samples shall not be damaged after impacting or leak after pressurizing. The average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.4 Puncture test

8.4.1 One set of three 92 cm (3 ft) samples of each aboveground pipe in worst case sizes shall be subjected to 13.6 kg (30 lb) point load for 1 h at 50 °C (122 °F) and -30 °C (-22 °F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10) each followed by a visual examination. After punctures at applicable temperatures, a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 shall be conducted at only laboratory temperature.

Exception: Pipe designs with exterior metal constructions need only be tested at the low temperature.

8.4.2 All samples shall rest on a hard surface, and the point load shall be applied at the pipe center perpendicular to the surface through a 5.0 mm (0.20 in) diameter steel shaft with a 1.0 mm (0.04 in) diameter tip and 30° edge. New locations shall be tested at each temperature.

8.4.3 The sample containment wall shall not be punctured or leak after pressurizing. The average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.5 Fitting torque test

8.5.1 One set of three 92 cm (3 ft) long samples of each aboveground pipe in worst case sizes with threaded fittings or bolted flanges shall each be connected to mating Schedule 40 steel pipe or bushing at 1.5 times the manufacturer's recommended torque, with one end of each sample assembled at 50 °C (122 °F) and -30 °C (-22 °F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10).

Exception: Pipe designs with metal fittings need only be tested at the low temperature.

8.5.2 Following assembly, fitting torque and visual examination at each temperature, the samples shall be subjected to a repeat Leakage Test according to Subsection 6.2, and the Breakdown Test according to Subsection 6.4 at only laboratory temperature.

8.5.3 The samples shall not leak when subjected to test torques or pressures. The average breakdown values shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.6 Pipe torque test

8.6.1 One set of three 92 cm (3 ft) long samples of each aboveground pipe in worst case sizes shall each be connected to a mating Schedule 40 steel pipe or bushing. The longitudinal pipe axis shall then be twisted 90° through the end fittings for 1 h at 50 °C (122 °F) and -30 °C (-22 °F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10).

Exception: Pipe designs with metal containment walls need only be tested at the low temperature.

8.6.2 Following assembly, pipe torque, and visual examination at each temperature, the samples shall be subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4, at only laboratory temperature.

8.6.3 The samples shall not leak when subjected to test torques or pressures. The average breakdown values shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.7 Tension test

8.7.1 One set of three 92 cm (3 ft) long samples of each aboveground pipe in worst case sizes shall be connected to mating fittings. The longitudinal pipe axis shall then be subjected to a tension load per Table 8.1 applied through the end fittings for 1 min at 50 °C (122 °F) and -30 °C (-22 °F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10).

Exception: Pipe designs of metal constructions need only be tested at the low temperature.

Table 8.1
Tension test loads

Pipe OD	Test load
12.7 mm (1/2 in)	136.1 kg (300 lb)
19.1 mm (3/4 in)	158.8 kg (350 lb)
25.4 mm (1.0 in)	181.4 kg (400 lb)
31.8 mm (1- 1/4 in)	226.8 kg (500 lb)
38.1 mm (1- 1/2 in)	272.2 kg (600 lb)
50.8 mm (2.0 in)	362.9 kg (800 lb)
63.5 mm (2- 1/2 in)	453.6 kg (1000 lb)
76.2 mm (3.0 in)	544.3 kg (1200 lb)
88.9 mm (3- 1/2 in)	635.0 kg (1400 lb)
101.6 mm (4.0 in)	725.7 kg (1600 lb)

8.7.2 Following assembly, pipe tension and visual examination at each temperature, the samples shall be subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

8.7.3 The samples shall not leak when subjected to test loads or pressures. The breakdown value for each sample shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.8 Compression test

8.8.1 One set of three 92 cm (3 ft) samples of each aboveground pipe in worst case sizes shall be connected to mated fittings. The pipe center and end sleeve shall then be subjected to separate 2224 N (500 lbm) compression loads applied through 7.6 cm (3.0 in) flat metal plates for 1 min at 50 °C (122 °F) and -30 °C (-22 ° F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10).

Exception: Pipe designs of metal constructions need only be tested at the low temperature.

8.8.2 Following assembly, pipe compression, and visual examination at each temperature, samples shall be subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

8.8.3 The samples shall not leak when subjected to test loads or pressures. The breakdown value for each sample shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.9 Bending test

8.9.1 One set of three samples at least 92 cm (3 ft) long of each aboveground pipe in worst case sizes shall be connected to mating fittings, then subjected to the applicable bending condition below for at least 1 min at 50 °C (122 °F) and -30 °C (-22 °F) or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10). Mandrels are not permitted to maintain the pipe arc:

a) For pipe with a marked bending radius – Bent 1.5 times below the manufacturer's minimum bending radius on a sample at least 92 cm (3 ft) long and with one end fitting fixed;

b) For pipe without a marked bend radius – Bent 1.5 times the center deflection distance of the longest filled pipe allowed between supports, and with a connector fitting in at the center.

Exception: Pipe designs of metal constructions need only be tested at the low temperature.

8.9.2 Following assembly pipe bending, and visual examination at each temperature, samples shall be subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

8.9.3 The samples shall not kink or leak when subjected to the bend arc or test pressures. The average breakdown values shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

8.10 Support bracket test

8.10.1 One set of worst case size aboveground pipe samples and their support as indicated below shall be subjected to a load of 2X the weight of a filled pipe supported by the manufacturers supplied or recommended supporting means for at least 1 min at 50 °C (122 °F) and -30 °C (-22 °F), or the optional Severe LT or Severe HT rating temperatures (refer to Clause 5.10). An alternate method for cases where full pipe lengths can't fit in an environmental chamber, the pipes are permitted to be at least 92 cm (3 ft) long, but the remaining filled length shall be added to the pipe end(s).

a) For horizontal pipe installations – The longest length of pipe supported/suspended by its intended brackets in a horizontal plane from at least one bracket attached to the pipe or fitting per the manufacturer's instructions;

b) For vertical pipe installations – The longest length of pipe supported/suspended by its intended brackets in a vertical plane from at least one bracket attached to the pipe or fitting per the manufacturer's instructions.

Exception: Pipe designs of metal constructions need only be tested at the low temperature.

8.10.2 Following assembly pipe bending, and visual examination at each temperature, samples shall be subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

8.10.3 The brackets shall not be damaged or fail, or the pipe leak when subjected to the loads. The average breakdown values shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

9 Tests for Optional Special Use Ratings

9.1 General

9.1.1 Aboveground pipe optionally rated for special uses shall be subjected to the additional requirements as follows for the applicable types:

a) Marinas where used on fixed piers and protected from impacts – Subsection 9.2 Corrosion Resistance Tests; and

b) Marinas where used on semi-fixed or floating docks and protected from impacts – Subsections 9.2 Corrosion Resistance Tests and 9.3 Tide Cycle Test.

NOTE 1 Fixed piers have no normal movement from waves/tides. Semi-fixed or floating docks are designed to move vertically with tides, but are not affected by normal wave actions.

NOTE 2 “Protected from impacts” is related to boats and vehicles, and is typically achieved by routing pipes under piers/docks or within structural channels.

9.2 Corrosion resistance tests

9.2.1 Two sets of three samples at least 60 cm (2 ft) long of each aboveground pipe in worst case sizes with plugged end fittings and one center joint (if different from end connections) shall be subjected to the Salt Fog Test according to Clause 9.2.2 and Corrosive Atmosphere Test exposures according to Clause 9.2.3.

9.2.2 After 400 h of expose in accordance with Standard Practice for Operating Salt Spray (Fog) Apparatus, ASTM B117, there shall be no more than 5 % base metal corrosion of the exposed surface and no visual pitting. Alternately, the average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average after conducting a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

9.2.3 After 1200 h of exposure to a CO_2/SO_2 atmosphere according to Clause 9.2.4, there shall be no more than 5 % base metal corrosion of the exposed surface and no visual pitting. Alternately, the average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average after conducting a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

9.2.4 Each day, 1 % CO_2 and 1 % SO_2 by volume shall be introduced into the test chamber, with each gas supplied from a controlled cylinder. The samples shall be supported in plastic racks at an angle of 15° from the vertical, and the test chamber shall be maintained at 35 ± 2 °C (95 ±3 °F). Prior to introducing the new charge of gas each day, the remaining gas-air mixture from the previous day shall be purged. A small amount of water shall be maintained at the chamber bottom for humidity, but shall not be changed during the exposure.

9.3 Tide cycle test

9.3.1 One set of three samples at least 3 m (10 ft) long of each aboveground pipe in worst case sizes with end fittings and one center joint (if different from end connections and permitted by the manufacturer for moving dock sections) shall be subjected to 10000 cycles of dynamic bending according to Clause 9.3.2.

9.3.2 The samples shall be filled with water and the pipe center flexed from 0 to 10° above the manufacturers minimum rated bend angle, but not less than 60°. The flexing shall be done at the manufacturers minimum rated bend radius (use of a mandrel is permitted) at a cycle rate of at least 1 cycle/min.

9.3.3 After completing the cycles, the samples shall be subjected to the repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature. There shall be no leakage, and average breakdown value for each sample set shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

10 Short-Term Compatibility Tests

10.1 General

10.1.1 Samples of each aboveground pipe type, construction, and size as indicated in each method shall be subjected to the following tests:

a) UV exposure test per Subsection 10.2 for all exposed exterior polymeric pipe surfaces;

b) Metallic stress test per Subsection 10.3 for Zn alloy pipe components;

c) Nonmetallic stress test per Subsection 10.4 for polyethylene (PE) pipe components.

10.1.2 Representative “worst case” samples may be used for pipe and fittings if materials, thickness, and process are consistent between nominal sizes or fitting types (straight, elbow or tee).

10.2 UV exposure test

10.2.1 Two 30 cm (12 in) samples of aboveground pipe designed with exposed polymeric exterior materials in representative worst case sizes, shall be subjected to either of the test methods below at a cycle rate of 17 min light and 3 min water. One sample shall be straight and the other bent to the manufacturer's minimum bend radius, if applicable.

a) 720 h (indoor rating), or 2880 h (outdoor rating) using the Apparatus and Procedures of Test Method 1, per ASTM G153, Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials; or

b) 1000 h (indoor rating), 4000 h (outdoor rating) using the Apparatus and Procedures of Test Method A, per ASTM G 155, Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials.

10.2.2 Following the UV exposure, samples shall be examined for damage and then subjected to a repeat Leakage Test according to Subsection 6.2 and Breakdown Test according to Subsection 6.4 at only laboratory temperature.

10.2.3 The samples shall not be damaged after UV exposure or leak after pressurizing. Each breakdown value shall be at least 1724 kPa (250 psig) (primary), and/or 1379 kPa (200 psig) (secondary), with the

average at least 5 times the rated pressure, or 70 % of the as-received laboratory temperature breakdown average.

10.3 Metallic stress crack test

10.3.1 For aboveground pipe constructed with threaded end fittings or bolted flanges containing at least 15 % zinc (excluding platings), one worst case fitting in all sizes shall be exposed to a moist ammonia-air mixture of minimum 600 ml (20 US fluid ounces) of 0.94 spg aqueous ammonia for 10 d at 34 °C (95 °F) in a heated water bath or oven.

10.3.2 All fitting samples shall be grease-free, assembled with steel plugs at the manufacturers recommended torque, and positioned above the ammonia in a suitable container.

10.3.3 Following the exposure, the samples are to be visually examined without magnification tools. The fittings shall not show any evidence of cracking, crazing, or similar damage.

10.4 Nonmetallic stress crack test

10.4.1 For aboveground pipe constructed with polyethylene (any type or percentage blend) that is in contact with fuel, one minimum 30 cm (12 in) long section of worst case pipe in all sizes shall be exposed to a 10 % poly-oxyethylated nonylphenol (Type CO-630 IGEPAL) water solution for 180 h at 60 °C (140 °F) in a heated water bath or oven.

NOTE : IGEPAL is a Trade Mark of Rhodia Operations.

10.4.2 All pipe samples shall be cleaned, bent to the manufacturers minimum bend radius, and immersed in the IGEPAL test solution.

10.4.3 Following the exposure, the samples are to be visually examined without magnification tools. The pipe shall not show any evidence of cracking, crazing, or similar damage.

11 Long-Term Compatibility Tests

11.1 Sets of at least three samples in 46 cm (18 in) lengths of all aboveground pipe types and constructions in representative worst case sizes for each exposure liquid and time period shall be subjected to the liquids and exposures specified in Table 11.1 to simulate long term compatibility to intended fuels and expected soil and environmental fluids.

Table 11.1
Compatibility test liquids

External Soil and Environmental Test Fluids at 40 °C (104 °F)	Flammable and Combustible Test Fuels at 40 °C (104 °F)
Ph 3.0 Sulfuric Acid	F75/B25a[e]
1 % Hydrochloric Acid[a]	F25/B75a[e]
1 % Nitric Acid[a]	C15/E85a[d]
Ph 12 Sodium Hydroxide	C75/E25a[d]
Ph 10 Sodium Carbonate/Bicarbonate[b]	Fuel Blend Stocks Options: M100, E100 and/or B100
Saturated Sodium Chloride or Sea Salt Brine for “Marina” rated pipes	Specialty Fuel Options – As requested by the piping manufacturer

Table 11.1 Continued on Next Page

Table 11.1 Continued

External Soil and Environmental Test Fluids at 40 °C (104 ° F)	Flammable and Combustible Test Fuels at 40 °C (104 °F)
Distilled Water[c]	Specialty Chemicals – As requested by the piping manufacturer
Air at 70 °C – Only for aboveground pipes with functional polymer or elastomer components	
1 – Test parameters, such as temperature and concentrations of media, are increased in severity over those of normal operating conditions to obtain observable deterioration in a reasonable time period. This accelerated test does not give a direct correlation with service performance. However, this method of testing yields comparative data on which to evaluate the product. 2 – ASTM Reference Fuel C and F are described in ASTM D 471, Test Method for Rubber Property – Effect of Liquids. Fuel C is a 50/50 blend of Octane and Toluene. Fuel F shall be Grade D2 S15.	
[a] Percentage by weight. [b] A pH 10 is obtained by mixing 10.6 grams per liter of sodium carbonate and 8.4 grams per liter of sodium bicarbonate. A pH meter shall be used to measure and adjust ratio of sodium carbonate to sodium bicarbonate to obtain a pH of 10. [c] Distilled water having a maximum total matter of 2.0 ppm and a maximum electrical conductivity of 5.0 microhms/cm at 25 °C (77 °F), as described for Type IV grade reagent water in the ASTM D 1193, Standard Specification for Reagent Water. [d] The chemical formulation for aggressive alcohols used in mixing C75/E25a and C15/E85a is found in Appendix A. C = ASTM Ref Fuel C and E = Ethanol. [e] The chemical formulation of UL B100 aggressive biodiesel as a test fuel component of F75/B25a can be found in Appendix A. B = UL B100 and F = ASTM Ref Fuel F.	

11.2 Specific test fluids may be waived for those materials that are known to be chemically inert at the prescribed fluids concentration and temperature (such as air oven for any metals or distilled water for aluminum).

11.3 Test fluids may be limited to the “worst case” in each family group (acids, bases, waters) for materials that are known to be chemically inert at the prescribed pH or concentration level and temperature (such as selecting salt water over distilled water for metals).

11.4 Regarding Clauses 11.2 and 11.3, consideration to waive or reduce test fluids for specific materials shall be based on published documents from independent sources, such as chemical corrosion guides and material property handbooks.

11.5 The exposure time period for each compatibility test liquid sample sets at the elevated temperature shall be either 180 d (for minimum 70 %) or 270 d (for minimum 50 %) related to physical property retentions according to Clause 11.11. Additional time periods requested by the manufacturer to evaluate sample preparation effectiveness or obtain analytical prediction data are not prohibited.

11.6 Prior to testing, the samples are to be preconditioned (at laboratory temperature only) to simulate expected transport, assembly, installation, and use physical abuses by subjecting the aboveground pipe sequentially to the following tests:

a) Drop Test according to Subsection 8.2;

b) Impact Test according to Subsection 8.3;

c) Puncture Test according to Subsection 8.4; and

d) Bending Test according to Subsection 8.9, except at rated minimum bend radius.

Exception: Drop, impact, and/or puncture preconditioning may be waived if there was no evidence of abuse on the design after initial test results, verified by:

a) No evidence of noncompliant damage after the test; and

b) At least 10 times the rated pressure, or 80 % average breakdown value retention.

11.7 All samples shall have surfaces exposed as specified in Table 11.2. Except air oven, all samples shall be exposed to both liquid and vapor phases by filling or immersing approximately half the sample with/in the test liquids, and vertically storing during the exposure time. End plugs or caps and sealing materials shall be compatible with the test liquid(s) to provide leak-tight containment.

NOTE: Samples may be periodically checked for loss of liquid (absorption or permeation), and topped off if necessary to maintain the original levels.

Table 11.2
Exposed surfaces for test samples

Pipe Type	Test Fuels	Soil Fluids	Air Oven
Primary	All	P E	All
Secondary	All	S E	All
Coaxial	All	S E	All
Exposed surfaces – I = Interior, E = Exterior and all surfaces Pipe containment type – P = Primary and S = Secondary			

11.8 All sample exposures specified in Table 11.2 are to be maintained over the entire test time period at the indicated temperatures ± 2 °C (± 4 °F) using a water bath, ambient room, or equivalent, for all liquid exposures and an air circulating oven for all air exposures.

11.9 Following each exposure time period, each set of samples are to be drained of any test liquids, towel dried, and visually examined for damage within 2 h of extraction from the test liquids. Pipe fittings and joints shall not be removed or reassembled before repeat of Physical Abuse Tests according to Clause 11.10 are conducted.

11.10 Following each exposure time period, post exposure sample preparation and visual examination, repeat Physical Abuse Tests below, followed by subsequent Leakage Tests according to Subsection 6.2 and Breakdown Tests according to Subsection 6.4 are to be conducted (at laboratory temperature only) within 16 to 32 h after extraction from the test liquid in accordance with the:

a) Tension Test according to Subsection 8.7 on sample 1;

b) Compression Test according to Subsection 8.8 on sample 2; and

c) Bending Test according to Subsection 8.9 on sample 3.

11.11 Following the test sequence, each sample shall not leak after pressurizing. The breakdown values of each sample shall be at least 1724 kPa (250 psig) for primary and/or 1379 kPa (200 psig) for secondary, with an average of at least 5 times the rated pressure, or either 70 % @ 180 d or 50 % @ 270 d compared with the as received breakdown average.

11.12 Following the exposures, there shall be no severe corrosion or excessive loss of protective coatings.

12 Fire Test

12.1 One 92 cm (3 ft) sample of all aboveground pipe types in worst case sizes shall be subjected to the hydrocarbon pool fire described in Clauses 12.2 to 12.4 for at least 30 min, or higher time options in 15 min increments up to 2 h while the primary pipe is filled with water at rated pressure, and the secondary pipe, if applicable, shall contain unpressurized air. The primary pipe and/or secondary pipe may be maintained at

2X rated pressure during the test to determine the time of any leakage if the alternate leak test method is used.

12.1.1 A repeat Leakage Test according to Subsection 6.2 shall then be conducted at laboratory temperature. Alternately, if the primary pipe and/or secondary pipe is continuously monitored at 2X rated pressure during the test, the data is permitted to be used to determine the leakage test results and time rating. Similarly, visual observations such as bursting or spraying are also permitted to be used.

12.1.2 Optional fire jackets to protect end connections used to seal and/or test the pipe, not including the actual pipe end being tested, are permitted if also included in applicable evaluations in the Physical Abuse, Short Term Compatibility, Long Term Compatibility Tests, supplied with the pipe, and included in the installation instructions.

12.2 The sample shall be capped/plugged at one end and connected to a metal pipe or tube with a shutoff valve, pressure gauge, pressure regulator or equivalent means at the other end to maintain the rated pressure throughout the fire exposure. The sample shall then be centered and supported 10 cm (4 in) above the rim of a steel liquid-tight fire pan, approximately 50 cm (20 in) ID by 15 cm (6 in) deep, so that one end fitting, and joints and at least half of the pipe length, or 50 cm (20 in) is exposed to the flame with or without the optional fire jacket described in Clause 12.1.

12.3 After the sample is positioned and pressurized, at least 3.8 L (1 U.S. gal) of commercial grade kerosene (K1) shall be ignited in the fire pan, followed by additional amounts of kerosene, as needed, to maintain the fire for the entire test time. Water may be used as a buffer for the delivery of additional fuel through a metal tube at the bottom of the pan with a control system. The pressure shall be monitored with water adjusted and/or steam removed as needed to maintain the pressure within ± 5 % of the rated value.

12.4 When the test reaches the required time, or a failure is identified, the fire shall be extinguished using an appropriate method that does not damage the sample. After cooling to laboratory temperature, the sample shall be visually examined for damage before repeat leak testing on only the pipe system, if the alternate leak test method is not used.

12.5 The primary pipe and secondary pipe shall not leak before the time it is rated for.

Exception 1: The secondary pipe is permitted to leak at the end fittings.

Exception 2: The secondary pipe is permitted to leak at a location other than at the fittings, if the markings and instructions require the piping system to be continuously monitored for interstitial leakages.

MANUFACTURING AND PRODUCTION TESTS

13 General

13.1 All pipe and fittings shall be subjected to material, process, and performance checks by the manufacturer to adequately control the quality of the products. Material checks shall include pre-process acceptance of raw materials and post process evaluations of critical properties. Process checks shall include process parameters (such as time, temperature, pressure or other machine settings). Details of the manufacturer's quality control program shall be documented, with at least Dimensional Checks according to Clause 13.2 and Leakage Test according to Clause 13.3 conducted.

13.2 Dimensional checks on finished pipe and fittings as specified in Clause 5.2 shall be conducted by the manufacturer to ensure compliance with the minimum thickness for laminates or co-extrusions and minimum/maximum ranges for inside and outside diameters. Random sampling of batches or lots shall be allowed if a minimum sampling plan of 1/30 m (1/100 ft) for pipe or 1/100 units for fittings is conducted.