High-pressure Fiberglass Line Pipe

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Foreword

This specification is under the jurisdiction of the American Petroleum Institute Subcommittee on Fiberglass and Plastic Tubulars. The purpose of this specification is to provide standards for high-pressure fiberglass line pipe and fittings for use in conveying produced fluids including oil, gas, nonpotable water, and mixtures thereof in the oil and gas producing industries.

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— the term “shall” denotes a minimum requirement in order to conform to the recommended practice;

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Attention Users of this Publication: This edition of API Specification 15HR supersedes the Third Edition and includes items approved by letter ballot. Those ballot approved items (substantive changes) are indicated with gray shading and red font, but API makes no warranty as to the accuracy of such notations. Non-substantive changes will not be indicated. Portions of this publication have been changed from the previous edition. In some cases the changes are significant, while in other cases the changes reflect minor editorial adjustments in order to conform to current API styling. Since the document was significantly reformatted from the previous edition, no attempt was made to indicate the location of changes with bar notations.

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1 Scope

1.1 Coverage

This specification was formulated to provide for the availability of safe, dimensionally, and functionally interchangeable high-pressure fiberglass line pipe with a pressure rating from 500 lbf/in.^{2} to 5000 lbf/in.^{2} (3.45 MPa to 34.5 MPa), inclusive, in 250 lbf/in.^{2} (1.72 MPa) increments for pipes ≤ than NPS 12 inches and 100 lbf/in.^{2} (0.69 MPa) increments for pipes > than NPS 12 inches. This specification is limited to mechanical connections and the technical content provides requirements for performance, design, materials, tests and inspection, marking, handling, storing, and shipping. Critical components are items of equipment having requirements specified in this document.

This specification is applicable to rigid pipe components made from thermosetting resins and reinforced with glass fibers. Typical thermosetting resins are epoxy, polyester, vinyl ester, and phenolic. Thermoplastic resins are excluded from the scope of this specification. Any internal liners applied shall be made also from thermosetting resins. Fiberglass line pipe for use in low-pressure systems are covered in API Spec 15LR.

This specification covers fiberglass pipe utilized for the production of oil and gas. Specific equipment covered by this specification is high-pressure line pipe and couplings, fittings, flanges, and reducers and adapters.

1.2 Application of the API Monogram

If product is manufactured at a facility licensed by API and it is intended to be supplied bearing the API Monogram, the requirements of Annex A apply.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. However, not all documents listed may apply to your specific needs. The body of the standard should be referred to for how these documents are specifically applied.

API Specification 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

API Specification 5B, *Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*, Fifteenth Edition, 2008

API Recommended Practice 5B1, *Gauging and Inspection of Casing, Tubing and Line Pipe Threads*

API Recommended Practice 15TL4, *Recommended Practice for Care and Use of Fiberglass Tubulars*

API Specification Q1, *Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry*

ANSI B16.5 [1], *Pipe Flanges and Flanged Fittings*

ASTM D1599 [2], *Standard Test Method for Short-Time Hydraulic Pressure of Plastic Pipe, Tubing and Fittings*

[1] American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, New York 10036, www.ansi.org.
[2] ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

ASTM D2105, *Standard Test Method for Longitudinal Tensile Properties of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Tube*

ASTM D2992, *Standard Practice for Obtaining Hydrostatic of Pressure Design Basis for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe and Fittings*

ASTM D3567, *Standard Practice for Determining Dimensions of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe and Fittings*

3 Terms, Definitions, Abbreviations, and Symbols

3.1 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1.1
adapters
Appurtenances that allow connecting components with different joining systems.

3.1.2
component
Any high-pressure line pipe, pipe connection, fitting, flange, adapter, reducer, or end of outlet connections covered by this specification.

3.1.3
date of manufacture
Date of cure.

3.1.4
fiberglass
A generic term for glass-fiber-reinforced thermosetting resins.

3.1.5
fittings
Tees, 90s, and 45s.

3.1.6
glass transition temperature
The midpoint of the inflection temperature of the DSC curve (heat flow vs temperature) for the first scan.

3.1.7
hoop tensile modulus
The hoop tensile stress divided by the hoop strain under the condition of uniaxial hoop tensile stress.

3.1.8
manufacturer
Refers to the firm, company, or corporation responsible for making and marking the product to warrant that this product conforms to the specification.

3.1.9
maximum allowable operating pressure
MAOP
The maximum pressure that the pipe would be exposed to during service conditions, including normal and upset/abnormal operating conditions.

3.1.10
minimum reinforced wall thickness
The lowest average fiber reinforced wall thickness, excluding any internal liner and exterior resin layer thickness.

NOTE See 8.4.6 for additional information.

3.1.11
pi tape
A tape used to measure circumference.

3.1.12
Poisson's ratio
The ratio of hoop strain to axial strain as measured by strain gauges with the tube loaded to the axial load that would be produced at the rated pressure of the sample.

3.1.13
prime connection
The manufacturer's standard joining system for straight pipe.

3.1.14
reducers
Components that allow pipes of different sizes to be connected.

3.1.15
serialization
Assignment of a unique code to each individual component to maintain traceability.

3.1.16
visual inspection
Examination of parts and equipment for visible defects in material and workmanship.

3.2 Abbreviations and Symbols

DSC	differential scanning calorimetry
LCL	lower confidence limit
LTHS	long-term hydrostatic strength
NPS	nominal pipe size
Tg	glass transition temperature

4 General Information

4.1 Service Conditions

The API 15HR Standard Pressure Rating is from 500 lbf/in.^{2} to 5000 lbf/in.^{2} (3.45 MPa to 34.5 MPa), inclusive, in 250 lbf/in.^{2} (1.72 MPa) increments for pipes ≤ NPS 12 inches and 100 lbf/in.^{2} (0.69 MPa) increments for pipes > NPS 12 inches, and the standard service conditions for API 15HR Standard Pressure Rating is as follows:

a) service life is 20 years;

b) service temperature is 150 °F (65 °C);

c) the fluid environment is salt water.

Axial loads shall include end loads due to pressure and bending, where the radius of curvature of the pipe divided by the outside radius of the pipe shall be greater than or equal to 1200.

Cyclic pressure variation shall include 3000 cycles from 0 % to 120 % of API 15HR Standard Pressure Rating. Cyclic pressure variation shall include 10^9 cycles with an R value of 0.9 (R = minimum pressure divided by maximum pressure).

Service conditions other than the API 15HR conditions are discussed in 6.1.2 and Annex B.

4.2 Unit Conversion

This specification uses USC units with metric units shown in parentheses. Nominal sizes may be shown as fractions. Metric conversions are provided in Table 1.

The following factors were used where conversions are appropriate:

1 inch (in.)	=	25.4 millimeters (mm) exactly
1 square inch ($in.^2$)	=	645.16 square millimeters (sq mm) exactly
1 foot (ft)	=	0.3048 meters (m) exactly
1 pound (lb)	=	0.45359 kilograms (kg)
1 pound per foot (lb/ft)	=	1.4882 kilograms per meter (kg/m)
1 pound per square inch (psi)	=	6.895 kilopascals (kPa) for pressure (1 Bar = 100 kPa)
	=	0.006895 megapascals (MPa) for stress
1 foot-pound (ft-lb)	=	1.3558 Joules (J) for impact energy
1 foot-pound (ft-lb)	=	1.3558 Newton-meters (N·m) for torque
Fahrenheit (°F) to Celsius (°C)	=	°C = $^5/_9$ (°F – 32) for absolute temperature conversion
Fahrenheit (°F) to Celsius (°C)	=	°C = $^5/_9$ (°F) for temperature rate change

4.3 Availability of Test Results

The manufacturer shall prepare a report as outlined in Table 1.

This report shall be kept on file with the manufacturer and a copy shall be available on request to each purchaser. Any variance from the above test procedures voids the test as having been conducted according to API 15HR. Any user company may witness representative testing of pipe and connections, observe manufacturer's testing procedures, or inspect test apparatus.

Prior to presenting results of tests in verbal or written reports, articles, or advertisements and stating that the tests were made in accordance with API 15HR, the manufacturer shall complete the report described above. This copy shall be dated and reported test results certified by a management official of the company. It shall be the responsibility

of the manufacturing company to maintain copies of the certified test results for a minimum of five years from the date the manufacturing of the product is discontinued.

When the results of the tests are presented in verbal or written reports, articles, or advertisements and state that the tests were made in accordance with API 15HR, such reports, articles, or advertisements shall be worded in a fashion that will not imply that API either recommends or disapproves use of the subject components.

Table 1—Outline of Report Requirements

Section	Description
6.1	Manufacturer's make-up procedure.
6.1.2	Report in accordance with ASTM D2992 and 6.1.2.
6.1.3	Report in accordance with ASTM D2992 and 6.1.3.
6.1.4	Report in accordance with ASTM D1599 and 6.1.4.
6.1.5	Report in accordance with ASTM D1599 and 6.1.5.
6.4.1	Report in accordance with ASTM D2992 and calculation of requalification long-term hydrostatic strength (LTHS).
9.1 c)	Report in accordance with manufacturers written test procedure.
9.1 d)	Report in accordance with Annex C.
9.1 e)	Report in accordance with Annex C.
9.1 f)	Report in accordance with Annex D.
8.1 g)	Report in accordance with ASTM D2105.
9.1 h)	Report in accordance with ASTM D1599.
9.2	For each qualified pipe, include a table showing inside diameter, minimum reinforced wall thickness, and hoop stress rated pressure.
Annex E	For all qualified components product characteristics outlined in Annex E.
Manufacturer's Table	A table listing all qualified components by size and pressure rating.

5 Purchasing Guidelines

5.1 General

5.1.1 Purpose

This section provides recommended guidelines for inquiry and purchase of API 15HR pipe or component. These guidelines consist of data sheets that should be completed by the purchaser.

5.1.2 Data Sheet

The data sheet is designed to perform two functions:

a) assist the purchaser in the procurement of the proper pipe or component;

b) assist the purchaser in communicating his/her particular needs and requirements, as well as information on the environment, to the manufacturer for his/her use in designing and producing pipe or component.

5.1.3 Use

A copy of the data sheet should be completed as accurately as possible. A copy of the data sheet should then be attached to the purchase order or request for proposal.

Figure 1 provides a format that may be used to document service conditions and requirements for ordering high-pressure fiberglass components.

Figure 1 is merely an example for illustration purposes only. [Each company should develop its own approach.] It is not to be considered exclusive or exhaustive in nature. API makes no warranties, express or implied, for reliance on or any omissions from the information contained in this document.

5.2 Pressure Ratings

It is recommended that the pipe be purchased by pressure rating. The user should purchase pipe suitable for the specific service conditions.

5.3 Components

Components, other than pipe, should be ordered on the basis of thread size and pressure rating.

6 Design

6.1 Performance Requirements

6.1.1 General

For 6.1.2 and 6.1.3, all performance pressure testing shall be conducted with water as the internal test fluid. The water may be fresh potable water or salt water containing no more than 4.7 oz/gal (35 g/L) of table salt (average salinity of typical sea water).

6.1.2 Pipe and Prime Connection

The published API 15HR Standard Pressure Rating shall be determined by the following method.

ASTM D2992 Procedure B with free ends shall be performed at 150 °F (65 °C) or higher. Each specimen that fails beyond 6000 hours shall have a prime connection at the center of each specimen. The number of samples and distribution of failure points shall be as follows from Table 2.

Failures less than 10 hours should not be included in the regression analysis. Regression testing completed prior to the 4th Edition of API 15HR that are inclusive of data points less than 10 hours can be recalculated after removing the data points. Fewer than 18 failures are allowed as long as the remaining data set complies with Table 2 distribution requirements.

The test sample shall be a size no smaller than 2 in. (50.8 mm) nominal diameter, with an outside diameter to minimum reinforced wall thickness ratio of 20 or less for scaling to be unlimited. If an outside diameter to minimum reinforced wall thickness ratio of greater than 20 is used, the tested ratio shall be the lower limit for scaling. The samples shall be assembled by the manufacturer's documented make-up procedure. Any ASTM D2992 test started after September 15th 1988 shall have differential scanning calorimetry (DSC) data on each sample in accordance with Annex H.

API Monogram required? Yes_____ No_____

Project(s) and location(s): _____

Maximum allowable operating pressure (MAOP): _____

Field Hydro Test Pressure (psi): _____

Temperature ranges anticipated:_____

Minimum ambient temperature: _____

Maximum fluid temperature: _____

Anticipated composition of fluids: CO_2 _____ ppm

H_2S _____ ppm

Hydrocarbon Analysis (Gas, Oil)

Salt Water _____%

Other _____

Anticipated future operations that would affect pressure, temperature, or fluid content:

(e.g. hot-oiling) _____

Future operating parameters: _____

Will inhibitors be used? _____

If yes, what type? _____

Anticipated flow rates: _____ BPD oil/condensate

_____ MCF/D gas

_____ BPD salt water

Will erosion be a concern? _____ Cause: _____

Operator or third-party witness? Yes _____ No _____

Delivery requirements: _____

Special shipping, packing, and storage instructions:_____

_____

Additional customer notes: _____

_____

Technical contact in buyer's organization:_____ Phone: _____

Figure 1—Example Form for Ordering High-pressure Fiberglass Components

Table 2—Sample Failure Distribution

Test Time (hours)	API 15HR Number of Failures (at least)
10 to 1000	4
1000 to 6000	3
>6000	6
>10,000	0
Total failures	18
NOTE Differs from ASTM D2992 Procedure B as no regression data beyond 10,000 hours is specifically required by API 15HR.	

The published API 15HR Standard Pressure Rating shall be calculated by the following equation and rounded down to the nearest integer multiple of 250 lbf/in.^{2} (1.72 MPa) for NPS ≤ 12 inches and 100 lbf/in.^{2} (0.69 MPa) for NPS > 12 inches:

$$P_r = \frac{2S_S S_f t}{D} \quad (1)$$

where

P_r is the API 15HR Standard Pressure Rating in lbf/in.^{2} (MPa) gauge;

S_s is the 95 % lower confidence limit (LCL) of the LTHS at 20 years in accordance with ASTM D2992 Procedure B at 150 °F (65 °C) or higher in lbf/in.^{2} (MPa);

S_f is the 0.67 service (design) factor (see Annex B);

t is the minimum reinforced wall thickness, in. (mm);

D is the average diameter (OD − t) or (ID + t), in. (mm):

where

ID is the inner diameter of the reinforced wall;

OD is the outer diameter of the reinforced wall.

Scaling based on the LCL shall be done using Equation 1.

If only one regression test as defined above is conducted, the API 15HR Standard Pressure Rating shall be based on that test and shall be valid up to and including the test temperature. Additional regression tests as defined above may be conducted. If additional regression tests as defined above are conducted, the following rules apply.

1) Pressure ratings at temperatures between the test temperatures shall be based on a linear interpolation between closest two temperatures at which tests have been conducted. No extrapolation beyond the

temperatures at which data is available is allowed. The pressure rating below the lowest temperature at which data is available shall be based on the lowest temperature at which data is available.

2) The API 15HR Standard Pressure Rating shall be at 150 °F (65 °C). This rating shall be based on data at 150 °F (65 °C) if available; otherwise, this rating shall be interpolated from data above and below 150 °F (65 °C).

3) The hydrostatic mill test pressure (see 8.4.1) shall be based on the API 15HR Standard Pressure Rating.

6.1.3 Fittings

The following shall apply for fittings.

a) Test the highest anticipated pressure class in the 4 in. (101.6 mm) size and its pipe and prime connection.

b) Test temperature, 150 °F (65 °C) or higher.

c) Pressure test 6 fittings of each type. At the manufacturer's option; the 90° may be used to qualify all elbows and couplings.

d) Each fitting shall be joined to pipe using the manufacturer's documented make-up procedure. Thread dimensions and DSC T_g shall be recorded for each fitting in accordance with Annex F.

e) The end caps shall be unrestrained and there shall be at least 12 in. (304.8 mm) of pipe between the end enclosure and the fitting. The assembly for each average time to failure shall be placed on test at the same pressures. The assemblies shall be on test at pressures such that two failures are obtained in each of the following time ranges—hours to failure (average of set):

   1) 10 to 100,

   2) 100 to 1000,

   3) greater than 2000.

f) Calculate a pressure regression line in accordance with ASTM D2992 and extrapolate it to 20 years. The 20-year value shall equal or exceed the 20-year 95 % LCL of the same pressure class pipe.

6.1.4 Fitting Short-term Failure Pressure

The following shall apply for the fitting short-term failure pressure.

a) Test two untested fittings of the same size, construction, and pressure class as tested in 6.1.3. Use the assembly procedure of 6.1.3 and also record thread dimensions and DSC T_g values.

b) Test the two fittings following ASTM D1599 (unrestrained ends) at ambient temperature (65 °F to 80 °F [18 °C to 27 °C]).

c) Establish the burst ratio the same as in 6.1.5. Other sizes and pressure classes of component shall equal or exceed the ratios established in 6.1.5.

6.1.5 Short-term Failure Pressure

The burst pressure capability of components shall be demonstrated by pressure testing two samples of each size, type, and pressure rating of component in accordance with ASTM D1599 (free end). Both samples shall be assembled using the manufacturer's documented make-up procedures. Thread dimensions including taper, lead,

angle, height, length, chamfer, and stand-off, and minimum reinforced wall thickness shall be recorded. Tests shall be conducted at ambient temperature. The ratio (R_4) for 4 in. (101.6 mm) components is defined by:

$$R_4 = \frac{P_{b4}}{P_{r4}} \tag{2}$$

where

R_4 is the ratio of average failure pressure and API 15HR Standard Pressure Rating for 4 in. (101.6 mm) component;

P_{b4} is the failure pressure (ASTM D1599, free end) of untested 4 in. (101.6 mm) component qualified in accordance with 6.1.5;

P_{r4} is the API 15HR Standard Pressure Rating for the 4 in. (101.6 mm) component qualified in accordance with 6.1.4.

The API 15HR Standard Pressure Rating for other sizes of components shall meet the following criteria from:

$$P_r = \frac{P_b}{R_4} \tag{3}$$

where

P_r is the API 15HR Standard Pressure Rating for component;

P_b is the failure pressure of component in accordance with ASTM D1599 (free end).

6.2 Dimensions

6.2.1 Length

Full-length joints of pipe shall be in lengths according to the following schedule measured to the nearest 1 ft (0.305 m).

Length 1	Length 2	Length 3
15 ft to 21 ft (4.57 m to 6.4 m)	21 ft to 34 ft (6.4 m to 10.64 m)	34 or more ft (10.64 or more m)

Jointers (two pieces coupled to make a standard length) shall constitute no more than 5 % of the full length joints of the order, but no length used in making a jointer shall be less than 5 ft (1.52 m).

6.2.2 Dimensional Tolerances

Tolerances on inside diameter, total wall thickness, minimum reinforced wall thickness, and outside diameter are defined in Table 3.

Table 3 does not intend to exclude or limit nominal diameters not listed. Until larger diameter dimensions are standardized and published in API 15HR, the minimum inside diameter for sizes not listed shall be agreed between the purchaser/user and manufacturer.

6.2.3 Flanges

Flange bolt circle and face dimensions shall be in accordance with ANSI B16.5.

Table 3—Tolerance on Dimensions

	Tolerance
Total wall thickness	+22.5 % –0 %
Minimum reinforced wall thickness	+22.5 % –0 %
Outside diameter, D, is governed by the inside diameter and wall thickness.	
Nominal Sizes in. (mm)	**Minimum Inside Diameter** in. (mm)
1 (25.4)	0.9 (22.9)
1 1/2 (38.1)	1.35 (34.3)
2 (50.8)	1.87 (47.5)
2 1/2 (63.5)	2.34 (59.6)
3 (76.2)	2.72 (69.1)
3 1/2 (88.9)	3.3 (83.8)
4 (101.6)	3.69 (93.7)
5 (127)	4.3 (109.2)
6 (152.4)	5.3 (134.6)
8 (203.2)	7.4 (188)
10 (254)	8.8 (223.5)
12 (304.8)	11.75 (298.4)
16 (406.4)	14.3 (363.2)

6.3 Threaded End Connections

6.3.1 General

Pipe shall be furnished as specified in the purchase order, with any of the following end finishes:

a) threaded and coupled,

b) threaded ends without couplings,

c) integral joints,

d) alternate pipe thread.

6.3.2 Standard Thread Design

The following shall apply for standard thread design.

a) Pipe threads shall conform to API 5B, 15th Edition, threads, with the thread dimensions in Table 7 and Table 14. For the purposes of this specification, lengths L_2 and L_4, in Table 7 and Table 14 of API 5B, 15th Edition, shall be minimum dimensions. Any extra threads shall be added to the tube side of the thread.

b) Thread tolerances are defined in Table 5 and Table 11 of API 5B, 15th Edition.

c) Round threads shall have a fully rounded thread root and crest as conceptually illustrated in Figure 4 and Figure 9 of API 5B, 15th Edition. For 8 round threads, thread root radius shall be 0.017 in. ±0.0015 in. (0.4318 mm ±0.0381 mm). Thread crest radius shall be 0.020 in. ±0.0015 in. (0.508 mm ±0.0381 mm). For 10 round threads, thread root radius shall be 0.014 in. ±0.0015 in. (0.3556 mm ±0.0381 mm). Thread crest radius shall be 0.017 in. ±0.0015 in. (0.4318 mm ±0.0381 mm).

d) Threads for the 10 in. (254 mm) size only shall be in accordance with Table 6 of API 5B, 15th Edition.

6.3.3 Alternate Pipe Connections

Alternate pipe connections shall be allowed and shall be identified by the letters A.C. following the "15HR" or API Monogram marking. Alternate pipe connections shall meet the performance requirements of this specification.

6.3.4 Gauging Practice for Threads and Pipe Connections

The following shall apply for gauging practice for thread and pipe connections.

a) *Gauging Practice for Standard Threads*—the manufacturer shall have working gauges calibrated and traceable to API Master gauges. The calibration of working gauges shall be in accordance with API 5B and in accordance with the quality management system. The manufacturer shall maintain all working gauges in such condition as to ensure that product threads gauged as required in API 5B are acceptable under that specification except as noted in 6.3.2 of this specification. Thread gauging procedures shall be in accordance with API 5B1.

b) *Gauging Practice for Alternate Pipe Connections*—the manufacturer shall determine and document critical inspection criteria and establish inspection methods to ensure non-standard "AC joints" meet minimum requirements; this includes owning or having access to master gauges as necessary to calibrate working gauges.

c) The use of master gauges in checking product threads should be minimized. Such use should be confined to cases of dispute that cannot be settled by rechecking the working gauge against the reference master. Good care should be exercised when the master gauge is assembled on a product thread.

6.4 Reconfirmation

6.4.1 Reconfirmation Tests for Pipe and Prime Connection

Changes as described in Annex E for previously qualified systems shall require the following minimum tests.

a) The long-term static LTHS shall be verified at 150 °F (65 °C), or higher temperature if so rated, after any changes as described in Annex E by conducting the abridged ASTM D2992.

b) Procedure B (free end) test as described in Section 12 of ASTM D2992. Test samples shall be assembled by the manufacturer's documented make-up procedure.

c) Test samples shall be a size no smaller than 2 in. (50.8 mm) nominal diameter. The same outside diameter to reinforced wall ratio (D/t) constraints as in 6.1.2 shall apply for reconfirmation.

6.4.2 Reconfirmation Tests for Other Components

The reconfirmation tests of 6.1.3, 6.1.4, and 6.1.5 shall be repeated after any change as described in Annex E.

7 Process of Manufacture and Material

7.1 Process of Manufacture

Pipe furnished to this specification shall be produced by filament winding or centrifugal casting methods. Components furnished to this specification shall be produced by compression molding, centrifugal casting, filament winding, or resin transfer molding methods.

7.2 Materials

The reinforced wall of pipe and components shall consist of thermosetting polymers reinforced with glass fibers. Acceptable polymers may include epoxy resins, polyester resins, and vinyl ester resins.

Other resins and reinforcements shall be considered for inclusion in this standard when evidence is presented to show that they are suitable for the applications covered by this standard.

8 Quality Program

8.1 Quality Manual

The manufacturer shall maintain a quality manual. All prior revisions shall be retained for a period of not less than 5 years.

8.2 Process Control Requirements

Manufacturer shall institute and maintain a process documentation program to assure communication of approved manufacturing procedures to qualified receiving, manufacturing, and quality control personnel and their respective supervisory personnel is to include the following functions:

a) raw material acceptance,

b) allowable mixing procedure(s),

c) fabrication practice(s),

d) cure procedure(s).

It shall be the responsibility of the manufacturing company to maintain copies of the document for a minimum of five years from the date the manufacturing of the product is discontinued.

8.3 Quality Control Equipment

8.3.1 General

Equipment used to inspect, test, or examine material or other equipment shall be identified, controlled, calibrated, and adjusted at specified intervals in accordance with documented manufacturer instructions, and consistent with referenced industry standards to maintain the accuracy required by this specification.

8.3.2 Dimensional Measuring Equipment

Dimensional measuring equipment shall be controlled and calibrated by the manufacturer’s written specification.

8.3.3 Pressure Measuring Devices

The following shall apply for pressure measuring devices.

a) Test pressure measuring devices shall be either pressure gauges or pressure transducers and shall be accurate to 2.0 % of full scale range or less.

b) The manufacturer shall own or have access to a dead weight testing device.

c) All pressure measuring devices shall be calibrated once every six months to maintain the required accuracy or calibrated when subjected to unusual or severe conditions, such as, would render its accuracy questionable.

8.4 Quality Control Tests

8.4.1 Hydrostatic Mill Test

Each component and length of pipe, including jointers, after being fully cured shall be hydrostatically tested at the manufacturer's facility to 1.5 times the standard pressure rating. Hydrostatic test pressure shall be maintained for a minimum of two minutes. No visual leaks or weeps are permitted in the pipes, components, or end connections. Tests shall include an attached coupling or integral joint and shall not have restrained ends. Test temperature shall be ambient.

8.4.2 Degree of Cure (Determination of T_g)

Degree of cure shall be determined by DSC according to Annex F at a minimum frequency of once per shift for each resin system used at each manufacturer's facility. DSC tests, in accordance with Annex F, shall also be conducted on fittings at a frequency of one per 100 units irrespective of size, type, or pressure rating. The T_g shall not be more than 9 °F (5 °C) below the minimum values measured in 6.1.2 and 6.1.5. This may be the same fitting used in 8.4.3.

8.4.3 Short-time Failure Pressure

Short-time hydraulic failure pressure testing shall be done in accordance with ASTM D1599 (free end). Test sample includes a complete fiberglass connection. Failure pressure shall be greater than the published short-time hydraulic pressure in 9.1 h) and greater than 85 % of the minimum failure pressure of that component in the testing done in accordance with 6.1.3. Pipe and components furnished to this specification shall be tested in accordance with this paragraph at a minimum frequency of one test per lot. A pipe lot shall consist of 5000 ft (1525 m) or fraction thereof for one size and wall thickness in continuous production. For other components, a lot shall consist of 100 units irrespective of size, type, or pressure rating.

8.4.4 Visual Inspection

All pipe furnished to this specification shall meet the visual inspection limits in Table 4.

8.4.5 Retest

If any component fails to conform to the specified requirements 8.4.2 and 8.4.3, the manufacturer may elect to make retests on two additional components from the same lot. If both of the retest specimens conform to the requirements, all remaining lengths in the lot shall be accepted. If one or both of the retest specimens fail to conform to the requirements, the tested lot shall be rejected. The manufacturer may elect to test individually the remaining components from the rejected lot.

Table 4 —Visual Inspection Standards

Defect	Description	Maximum Size
Pipe Body and Component		
Burn	Thermal decomposition evidenced by distortion or discoloration of the surface.	20 % area—lightly blemished; 5 % area—moderate burn of outer resin layer structural roving.
Chip	Small piece broken from edge or surface.	Permitted if laminate has not been fractured.
Crazing	Fine cracks at or under the surface as seen by the unaided eye.	None permitted.
Cut roving	Broken or cut outer rovings due to scraping or scuffing or manufacturing process.	Maximum 3 per pipe with 1 $in.^2$ (25.4 mm^2) Maximum 6 such that the wall thickness is not reduced below minimum.
Dry spot	Area where reinforcement was not thoroughly wet with resin.	None permitted.
Fracture	Rupture of laminate without complete penetration. Visible as lighter colored area of interlaminar separation.	None permitted.
Pits (pinholes)	Small craters in the surface.	Maximum 1/16 in. (1.5875 mm) deep, no limit on number.
Resin drip	Resin protrusion.	Maximum 1/8 in. (3.175 mm) high, no limit on number.
Restriction	Any restriction: paste, epoxy or wax, lump, foreign matter in ID of pipe.	None permitted.
Scratch	Shallow mark caused by improper handling.	No limit on number if reinforcement is not exposed. If reinforcement is exposed, use cut roving.
Inclusions	Foreign matter wound into laminate.	None permitted.
Threads		
Air bubbles	Small bubbles at crest of threads.	Maximum size 1/8 in. (3.175 mm), 1 permitted per thread. Maximum size 1/16 in. (1.5875 mm), 10 permitted per thread.
Chips	Areas where over 10 % of thread height is removed.	Maximum 3/8 in. (9.525 mm) long, 1 permitted per thread outside the L_C area. None are permitted in L_C area.
Cracks	In direction of thread axis.	None permitted.
Flat thread	Area where top of thread is broken or ground off.	Maximum 3/8 in. (9.525 mm) long, one permitted per thread outside the L_C area, not to exceed 10 % of the thread height. None permitted in the L_C area.
Squareness	Angle perpendicular to thread, axis.	Maximum 1/16 in. (1.5875 mm) variation in end.
Finish	Finish cut end.	No sharp edges. No exposed loose fiber. No protrusions. No impact areas.

8.4.6 Wall Thickness

Total wall thickness shall be determined by caliper, eddy current thickness gauge, or pi tape on the outside diameter and calculate thickness based on measured inside diameter on every joint away from the upset. Minimum reinforced wall thickness shall be determined and reported in accordance with 7.3.2 and 7.5.2, respectively, of ASTM D3567-97 once every lot. The average reinforced wall thickness of any pipe cross section measured by six observations in accordance with ASTM D3567-97 shall meet or exceed the manufacturer's published minimum value. The also applies in qualification and verification activities. Total and reinforced wall tolerances shall be as specified in Table 3.

8.4.7 Thread Gauging

Threads shall be gauged in accordance with API 5B1. The minimum frequency of gauging shall be once per lot. For molded threads the first article from a new mold shall also be checked.

8.5 Inspection and Rejection

When stated on the purchase order, the provisions of Annex G shall apply.

8.6 Quality Control Records Requirements

8.6.1 Purpose

The quality control records required by this specification are necessary to substantiate that all materials and products made to meet this specification do conform to the specified requirements.

8.6.2 Records Control

The following shall apply for records control.

a) Quality control records required by this specification shall be legible, identifiable, retrievable, and protected from damage, deterioration, or loss.

b) Quality control records required by this specification

c) shall be retained by the manufacturer for a minimum of five years following the date of manufacture.

d) All quality control records required by this specification shall be signed and dated.

8.6.3 Records to be Maintained by Manufacturer

Test results shall be in accordance with 8.4.

9 Published Values

9.1 Published Properties

Certain properties do not have specified requirements but are nevertheless important in pipe system design. The manufacturer shall perform the required tests and publish values for these additional pipe properties.

a) Maximum rated temperature, °F (°C).

b) The LTHS and LCL as described in 6.1.2.

c) A value for the thermal coefficient of expansion in the axial direction over the ranges from 32 °F to 73.4 °F (0 °C to 23 °C), and from 73.4 °F (23 °C) to the maximum rated temperature, shall be determined in accordance with the manufacturer's written test procedure.

d) Hoop tensile modulus at 73.4 °F (23 °C) and at the maximum rated temperature in accordance with Annex C.

e) Poisson's ratio for a hoop tensile load and the resulting axial contraction at 73.4 °F (23 °C) and at the maximum rated temperature in accordance with Annex C.

f) Poisson's ratio for an axial tensile load and the resulting hoop contraction at 73.4 °F (23 °C) and at the maximum rated temperature in accordance with Annex D.

g) Axial tensile modulus of elasticity at 73.4 °F (23 °C) and at the maximum rated temperature in accordance with ASTM D2105.

h) Short-term hydraulic failure pressure of pipe across the connection at 73.4 °F (23 °C) and at the maximum rated temperature in accordance with ASTM D1599 (free end).

9.2 Published Dimensions

Manufacturers shall publish the following information for each qualified product:

a) nominal ID,

b) nominal OD,

c) nominal coupled weight,

d) maximum coupling or integral joint outside diameter,

e) nominal wall thickness,

f) minimum reinforced wall thickness.

10 Equipment Marking

10.1 Methods

Components manufactured in conformance with this specification shall be marked by the manufacturer as specified in 10.2. Additional markings as desired by the manufacturer or as requested by the purchaser are not prohibited. Markings shall be applied by paint or ink stencil, decal, or both. Markings shall not overlap and shall be applied in such manner as not to injure the pipe or couplings. Markings shall be legible for a period of three years in storage from the date of manufacture. Markings shall be applied on the pipe from 1 ft to 3 ft (0.305 m to 0.91 m) from the box connection.

10.2 Marking Requirements

Components shall be marked with the following:

a) manufacturer's name or mark;

b) "15HR" (add A.C. notation in accordance with 6.3.3 if applicable);

c) nominal size;

d) unique identification number (serialization);

e) API 15HR Standard Pressure Rating;

f) date of manufacture;

g) API 15HR standard temperature rating of 150 °F (65 °C); and

h) additional information as requested by the purchaser (e.g. rating at higher temperature).

11 Handling, Packaging, Storing, and Shipping Requirements

11.1 Coupling Make-up and Thread Compounds

All couplings shall be threaded onto the pipe by the manufacturer's documented make-up procedure; they shall be threaded on handling-tight, or shipped separately, if specified on the purchase order. A thread lubricant/sealant shall be applied to cover the full surfaces of the engaged threads of the coupling and pipe before making up the joint. The specified type of lubricant/sealant and make-up procedure shall be that recommended by the manufacturer.

11.2 Thread Protectors

The manufacturer shall apply external and internal closed end thread protectors to protect the ends and all exposed threads of the pipe, coupling, and fitting from damage under normal handling and transportation. Thread protectors shall exclude foreign matter such as dirt from the ends and threads for storage. Protector material shall be plastic and contain no compounds capable of damaging the threads or promoting adherence of the protectors to the threads and shall be suitable for service temperatures of –50 °F to +150 °F (–45.55 °C to +65.55 °C).

11.3 Flange Face Protectors

Manufacturers shall apply flange face protectors to all flange faces in accordance with standard industry practice.

11.4 Packaging, Shipping, and Handling Requirements

Manufacturers shall comply with API 15TL4.

12 Field Pressure Testing

The recommended field pressure test is 1.25× the maximum system design pressure (see ASME B31.4 – 437.4.3 Leak Testing for hydrocarbon lines). The maximum field pressure test should not exceed 1.25× the API 15HR Standard Pressure Rating as marked on the pipe and components. This limitation is intended to avoid exceeding stresses produced during the factory hydrostatic mill test (see 8.4.1). The manufacturer should be consulted in cases where the field test pressure may exceed 1.25× the API 15HR Standard Pressure Rating. The field test pressure should be measured at the lowest elevation in the piping system.

Additional axial stress may still be imposed on a pipe system due to bending radius and thermal effects specific to the installation. In cases where combined axial stress may approach the long-term limitations, a detailed stress analysis is recommended to determine the maximum field test pressure.

See API 15TL4 for test duration.

Annex A
(informative)

Use of API Monogram by Licensees

A.1 Scope

The API Monogram® is a registered certification mark owned by the American Petroleum Institute (API) and authorized for licensing by the API Board of Directors. Through the API Monogram Program, API licenses product manufacturers to apply the API Monogram to new products that comply with product specifications and have been manufactured under a quality management system that meets the requirements of API Q1. API maintains a complete, searchable list of all Monogram licensees on the API Composite List website (www.api.org/compositelist).

The application of the API Monogram and license number on products constitutes a representation and warranty by the licensee to API and to purchasers of the products that, as of the date indicated, the products were manufactured under a quality management system conforming to the requirements of API Q1 and that the product conforms in every detail with the applicable standard(s) or product specification(s). API Monogram program licenses are issued only after an on-site audit has verified that an organization has implemented and continually maintained a quality management system that meets the requirements of API Q1 and that the resulting products satisfy the requirements of the applicable API product specification(s) and/or standard(s). Although any manufacturer may claim that its products meet API product requirements without monogramming them, only manufacturers with a license from API can apply the API Monogram to their products.

Together with the requirements of the API Monogram license agreement, this annex establishes the requirements for those organizations who wish to voluntarily obtain an API license to provide API monogrammed products that satisfy the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program requirements.

For information on becoming an API Monogram Licensee, please contact API, Certification Programs, 1220 L Street, N. W., Washington, DC 20005 or call 202-682-8145 or by email at certification@api.org.

A.2 Normative References

API Specification Q1, *Specification for Quality Management System Requirements for Product Manufacturing for the Petroleum and Natural Gas Industry*

A.3 Terms and Definitions

A.3.1
API monogrammable product
Product that has been newly manufactured by an API licensee utilizing a fully implemented API Q1 compliant quality management system and that meets all the API specified requirements of the applicable API product specification(s) and/or standard(s).

A.3.2
API specified requirements
Requirements, including performance and licensee-specified requirements, set forth in API Q1 and the applicable API product specification(s) and or standard(s).

NOTE Licensee-specified requirements include those activities necessary to satisfy API specified requirements.

A.3.3
API product specification
Prescribed set of rules, conditions, or requirements attributed to a specified product that address the definition of terms; classification of components; delineation of procedures; specified dimensions; manufacturing criteria; material requirements, performance testing, design of activities; and the measurement of quality and quantity with respect to materials; products, processes, services, and/or practices.

A.3.4
licensee
Organization that has successfully completed the application and audit process and has been issued a license by API.

A.3.5
design package
Records and documents required to provide evidence that the applicable product has been designed in accordance with API Q1 and the requirements of the applicable product specification(s) and/or standard(s).

A.4 Quality Management System Requirements

An organization applying the API Monogram to products shall develop, maintain, and operate at all times a quality management system conforming to API Q1.

A.5 Control of the Application and Removal of the API Monogram

Each licensee shall control the application and removal of the API Monogram in accordance with the following.

a) Products that do not conform to API specified requirements shall not bear the API Monogram.

b) Each licensee shall develop and maintain an API Monogram marking procedure that documents the marking/ monogramming requirements specified by this annex and any applicable API product specification(s) and/or standard(s). The marking procedure shall:

   1) define the authority responsible for application and removal of the API Monogram;

   2) define the method(s) used to apply the API Monogram;

   3) identify the location on the product where the API Monogram is to be applied;

   4) require the application of the licensee's license number and date of manufacture of the product in conjunction with the use of the API Monogram;

   5) require that the date of manufacture, at a minimum, be two digits representing the month and two digits representing the year (e.g. 05-12 for May 2012) unless otherwise stipulated in the applicable API product specification(s) or standard(s); and

   6) require application of the additional API product specification(s) and/or standard(s) marking requirements.

c) Only an API licensee may apply the API Monogram and its designated license number to API monogrammable products.

d) The API Monogram license, when issued, is site-specific and subsequently the API Monogram shall only be applied at that site specific licensed facility location.

e) The API Monogram may be applied at any time appropriate during the production process but shall be removed in accordance with the licensee's API Monogram marking procedure if the product is subsequently found to be out of conformance with any of the requirements of the applicable API product specification(s) and/or standard(s) and API Monogram Program.

For certain manufacturing processes or types of products, alternative API Monogram marking procedures may be acceptable. Requirements for alternative API Monogram marking are detailed in the API Policy, ***API Monogram Program Alternative Marking of Products License Agreement***, available on the API Monogram Program website at http://www.api.org/alternative-marking.

A.6 Design Package Requirements

Each licensee and/or applicant for licensing shall maintain a current design package for all of the applicable products that fall under the scope of each Monogram license. The design package information shall provide objective evidence that the product design meets the requirements of the applicable and most current API product specification(s). The design package(s) shall be made available during API audits of the facility.

In specific instances, the exclusion of design activities is allowed under the Monogram Program, as detailed in *Advisory # 6*, available on API Monogram Program website at http://www.api.org/advisories.

A.7 Manufacturing Capability

The API Monogram Program is designed to identify facilities that have demonstrated the ability to manufacture equipment that conforms to API specifications and/or standards. API may refuse initial licensing or suspend current licensing based on a facility's level of manufacturing capability. If API determines that additional review is warranted, API may perform additional audits (at the organization's expense) of any subcontractors to ensure their compliance with the requirements of the applicable API product specification(s) and/or standard(s).

A.8 API Monogram Program: Nonconformance Reporting

API solicits information on products that are found to be nonconforming with API specified requirements, as well as field failures (or malfunctions), which are judged to be caused by either specification deficiencies or nonconformities with API specified requirements. Customers are requested to report to API all problems with API monogrammed products. A nonconformance may be reported using the API Nonconformance Reporting System available at http://compositelist.api.org/ncr.asp.

Annex B
(informative)

Service (Design) Factors

Consideration is being given to adopting a more comprehensive method of determining the pipe and prime connection pressure performance. The overall service (design) factor, S_f in Equation 1, will be the product of the individual service factors, thus permitting adjustment of the API 15HR Standard Pressure Rating for specific applications having other than the defined standard conditions as illustrated:

$$S_f = SF^C \times SF^E \times SF^L \times SF^T \times SF^A \quad \text{(B.1)}$$

where

S_f is the overall service (design) factor used in Equation 1;

SF^C is the service factor for cyclic pressure variations, which will be based on results of a test program currently being defined;

SF^E is the service factor for environment, which will be based on a test program being evaluated;

SF^L is the service factor for design life, which will be defined by:

$$SF^L = \frac{\text{LCL @ design life \& 150 °F (65 °C)}}{\text{LCL @ 20 years \& 150 °F (65 °C)}} \quad \text{(B.2)}$$

LCL at a higher temperature may be substituted for LCL @ 150 °F (65 °C);

SF^T is the service factor for temperature, which will be defined by:

$$SF^T = \frac{\text{LCL @ design temperature \& 20 years}}{\text{LCL @ 150 °F (65 °C) \& 20 years}} \quad \text{(B.3)}$$

LCL at a higher temperature may be substituted for LCL @ 150 °F (65 °C).

LCL at design temperature can be determined by interpolation when LCLs are available for temperatures higher and lower than the design temperature. Otherwise, an LCL at a temperature higher than the design temperature shall be used.

At no time should a pipe be used for extended service at a temperature higher than that for which an LCL has been generated.

SF^A is the service factor for additional axial loads (less than or equal to 1.0), which will be defined by:

$$SF^A = \frac{sAP - sAA}{sAP} \quad \text{(B.4)}$$

where

sAP is the axial stress due to the API 15HR pressure rating $= \frac{P_R R_i^2}{(R_o^2 - R_i^2)}$;

sAA is the axial stress due to additional axial loads, for example bending a pipe to a certain radius of curvature, where sAA would be calculated by:

$$sAA = \frac{E_A R_o}{R_c} \tag{B.5}$$

where

E_A is the axial modulus of elasticity in lbf/in.^{2} (MPa);

R_c is the radius of curvature in inches (mm).

Annex C
(normative)

Determination of the Hoop Tensile Modulus and Poisson's Ratio

C.1 General

This annex describes a method to determine the hoop tensile modulus and Poisson's ratio for a hoop tensile load and the resulting axial contraction.

C.2 Apparatus

C.2.1 A pressure source with a calibrated pressure measuring device.

C.2.2 Strain gauge monitoring equipment and gauges.

C.2.3 A test fixture as shown in Figure C.1.

C.3 Test Specimens

C.3.1 Size

The sample length, L, shall be at least 10 times the nominal pipe outside diameter.

C.3.2 Number of Specimens

Three specimens shall be tested for each pipe being evaluated.

C.3.3 Sample Selection

The samples selected shall be standard production pipe.

C.4 Test Procedure

C.4.1 Apply two strain gauges to each specimen as shown in Figure C.1. One strain gauge shall be oriented to measure strain in the axial direction. The other strain gauge shall be oriented to measure strain in the hoop direction. Standard strain gauging practices shall be followed.

C.4.2 Insert the test fixtures into the test specimen as shown in Figure C.1.

C.4.3 Zero the strain gauges.

C.4.4 Pressurize the specimen to its rated internal pressure.

C.4.5 Record the hoop and axial strain.

C.4.6 Poisson's ratio is the axial strain divided by the hoop strain.

C.4.7 Determine the hoop stress by:

$$h = P\frac{R_o^2 + R_i^2}{R_o^2 - R_i^2} \quad \text{(C.1)}$$

where

h is the hoop stress in lbf/in.^{2} (MPa);

P is the internal pressure in lbf/in.^{2} (MPa);

R_i is the inside radius of the structural wall in inches (mm);

R_o is the outside radius of the structural wall in inches (mm).

The inside diameter and structural wall thickness shall be determined by ASTM D3567.

Hoop tensile modulus is the hoop tensile stress divided by the hoop strain.

C.5 Report

The report shall include the following items.

C.5.1 Complete identification of the test samples including material and manufacturer's name.

C.5.2 Pipe dimensions, including nominal size, minimum reinforced wall thickness, inside diameter, and length.

C.5.3 The applied pressure.

C.5.4 The measured hoop and axial strain, and the calculated hoop stress, for each sample.

C.5.5 The mean hoop tensile modulus and Poisson's ratio.

C.5.6 The test temperature.

C.5.7 Start date and completion of tests.

C.5.8 Test laboratory and supervisor of tests.

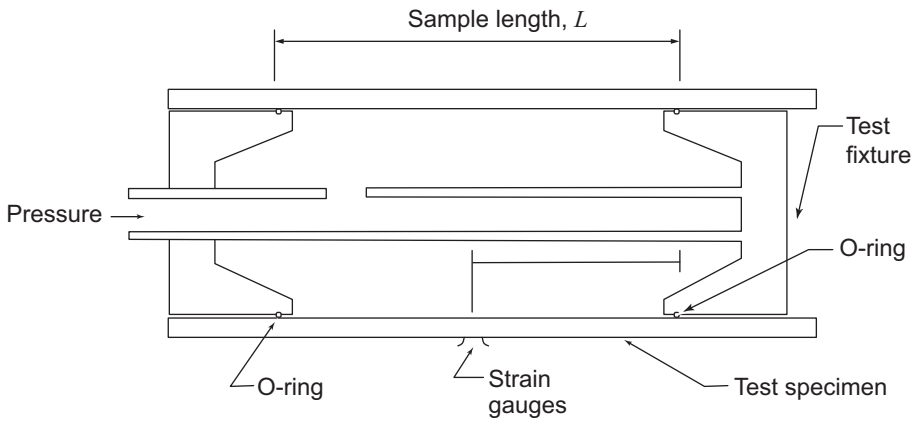

Figure C.1—Typical Test Setup to Determine Hoop Tensile and Poisson Ratio

Annex D
(normative)

Determination of the Axial Tensile Poisson's Ratio

D.1 General

This annex describes a method to determine the Poisson's ratio for an axial tensile load and the resulting hoop contraction.

D.2 Apparatus

D.2.1 A testing machine and grips that meets the requirements set forth in 5.1, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5, and 5.1.6 of ASTM D2105-85.

D.2.2 Strain gauge monitoring equipment and gauges.

D.3 Test Specimens

D.3.1 Size

The sample length shall be a minimum of 18 in. (457.2 mm) between grips.

D.3.2 Number of Specimens

Three specimens shall be tested for each pipe being evaluated.

D.3.3 Sample Selection

The sample selected shall be standard production pipe.

D.4 Test Procedure

The procedure shall be performed as follows.

D.4.1 Apply two strain gauges to each specimen as shown in Figure C.1. One strain gauge shall be oriented to measure strain in the axial direction. The other strain gauge shall be oriented to measure strain in the hoop direction. Standard strain gauging practices shall be followed.

D.4.2 Insert the test sample into the testing machine in accordance with 9.2 of ASTM D2105-85.

D.4.3 Zero the strain gauges.

D.4.4 Set the speed of testing in accordance with 9.3.1 or 9.3.2 of ASTM D2105-85.

D.4.5 Load the sample up to the axial load that would be produced at the rated pressure of the sample.

If the correct equipment is available, the strains and loads can be recorded continuously, or in accordance with 9.4 of ASTM D2105-85, and the sample taken to failure. This would allow the axial tensile modulus of elasticity to be determined at the same time as the Poisson's ratio. Follow ASTM D2105-85, but use the axial tensile strain gauge as the extension indicator.

D.4.6 Axial Poisson's ratio is the hoop strain divided by the axial strain.

D.5 Report

The report shall include the following items.

D.5.1 Complete identification of the test samples including material and manufacturer's name.

D.5.2 Pipe dimensions, including nominal size, minimum reinforced wall thickness, inside diameter, and length.

D.5.3 The applied load.

D.5.4 The measured hoop and axial strain at the applied load for each sample.

D.5.5 The mean axial tensile Poisson's ratio.

D.5.6 The test temperature.

D.5.7 Start date and completion of tests.

D.5.8 Test laboratory and supervisor of tests.

Annex E
(normative)

Product Characteristics

It is the intention of this specification that ALL test samples be as representative of actual production line components as possible. The following characteristics shall be the same for samples and production line components (within the manufacturer's documented production tolerances where applicable). Changes in the following characteristics of the piping system's components shall require testing in accordance with 6.4.

E.1 Reinforcement

— Manufacturer

— Production designation to include reference to the following.

  — mean filament diameter

  — finish (sizing) type and amount

  — type (single or multiple end)

  — chemical composition of fiber

  — yield

E.2 Resin Matrix

— Manufacturer

— Product designation

E.3 Curing Agent

— Manufacturer

— Product designation

E.4 Liner (If Used)

— Resin manufacturer

— Resin product designation

— Reinforcement (if used) subject to above characterization thickness

— Cure temperature and time schedule if different from component

— Curing agent (subject to above characterization)

— Thickness (change resulting is any reduction in liner thickness)

E.5 Manufacturing

— Winding angle (change greater than ±5°)

— Glass transition temperature as determined in Annex F (change resulting in reduction greater than 18 °F (10 °C) under the standard T_g)

— Facility location (excludes expansion as a current facility)

E.6 Report

Documentation of each applicable product characteristic shall be included for each component size and rating.

Annex F
(normative)

Test Method for Determination of Degree of Cure (T_g) by Differential Scanning Calorimetry

F.1 General

This test determines the degree of cure of a fiberglass pipe and component test specimen relative to statistically significant values obtained from typical production product.

F.2 Apparatus

The DSC equipment shall be calibrated in accordance to the DSC manufacturer at a frequency specified by the DSC manufacturer or at six-month intervals, whichever is shorter.

F.3 Test Specimens

F.3.1 Size

The size of the specimen is limited by the size of the DSC sample pan. All specimens can be a chip or filed into a fine powder to provide easy weighing and uniform contact with the pan.

F.3.2 Location

For any given tubular product, a sample shall be taken 0 mils to 10 mils (0 mm to 0.254 mm) from the outer surface for internally cured products, or 0 mils to 10 mils (0 mm to 0.254 mm) from the inner surface for externally cured products. If the sample has a liner, then a specimen shall be taken from the liner as well as the inner or outer edges of the reinforced wall.

F.4 Procedure

The procedure shall be performed as follows.

F.4.1 Maximum heating rate is 72 °F/min (40 °C/min).

F.4.2 Run the scan from room temperature to at least 86 °F (30 °C) above the expected glass transition temperature and no more than 482 °F (250 °C).

F.4.3 Obtain the T_g.

F.5 Report

The report shall include the following items.

F.5.1 Complete identification of the specimens that include material, manufacturer's name, and lot number; Pipe dimensions that include nominal size, minimum reinforced wall thickness, and average outside diameter; and unreinforced thicknesses (i.e. liner).

F.5.2 Number of specimens tested and where the specimens were taken from the pipe.

F.5.3 Heat-up rate for DSC temperature scans.

F.5.4 Record the inflection value for the first scan as the glass transition temperature, T_g.

F.5.5 Date of test.

F.5.6 Test laboratory and supervisor of tests.

Annex G
(informative)

Purchaser Inspection

G.1 Inspection Notice

Where the inspector representing the purchaser desires to inspect this pipe or witness these tests, reasonable notice shall be given of the time at which the run is to be made.

G.2 Inspection Location

All inspections should be made at the place of manufacture prior to shipment, unless otherwise specified on the purchase order, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

G.3 Compliance

The manufacturer is responsible for complying with all of the provisions of this specification. The purchaser may conduct an investigation necessary to assure compliance by the manufacturer and may reject any material that does not comply with this specification.

G.4 Rejection

Unless otherwise provided, material that shows defects on inspection or subsequent to acceptance at the manufacturer's works, or material that proves defective when properly applied in service, may be rejected, and the manufacturer so notified. If tests that require the destruction of material are made, any product that is proven to have not met the requirements of the specification shall be rejected. Disposition of rejected product shall be a matter of agreement between the manufacturer and the purchaser.

Bibliography

[1] API Specification 15LR, *Specification for Low Pressure Fiberglass Line Pipe*

[2] ASME B31.4 [3], *Pipeline Transportation Systems for Liquids and Slurries*

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

[4] ASTM D2143, *Standard Test Method for Cyclic Pressure Strength of Reinforced, Thermosetting Plastic Pipe*

[3] ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.

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