Specification for High Pressure Fiberglass Line Pipe

Upstream Segment

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FOREWORD

a. This specification is under the jurisdiction of the American Petroleum Institute Subcommittee on Fiberglass and Plastic Tubulars.
b. 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.
c. Nothing in this specification should be interpreted as indicating a preference by the committee for any material or process or as indicating equality between the various materials or processes. In the selection of materials and processes, the purchaser must be guided by his experience and by the service for which the pipe is intended.
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f. The procedure for obtaining authorization to use the API monogram is given in Appendix I.
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Specification for High Pressure Fiberglass Line Pipe

1 Scope

1.1 PURPOSE

1.1.1 This specification was formulated to provide for the availability of safe, dimensionally and functionally interchangeable high pressure fiberglass line pipe with a Specification 15HR Standard Pressure Rating from 500 lbf/in.^{2} to 5000 lbf/in.^{2}, inclusive, in 250 lbf/in.^{2} increments. This specification is limited to mechanical connections.

1.1.2 Technical content provides requirements for performance, design, materials, tests and inspection, marking, handling, storing and shipping.

1.1.3 Critical components are items of equipment having requirements specified in this document.

1.2 APPLICATIONS

1.2.1 Equipment

This specification covers fiberglass pipe utilized for the production of oil and gas. Specific equipment covered by this specification is listed as follows:

High pressure line pipe and couplings.

Fittings.

Flanges.

Reducers and adapters.

1.2.2 Service Conditions

The standard service conditions for Specification 15HR Standard Pressure Rating are as follows:

Service life is 20 years.

Service temperature is 150°F.

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 3,000 cycles from 0 to 120% of Specification 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 standard Specification 15HR conditions are discussed in 5.1.1 and Appendix G.

1.3 UNIT CONVERSION

A decimal/inch system is the standard for the dimensions shown in this specification. Nominal sizes will continue to be shown as fractions. For the purposes of this specification, the fractions and their decimal equivalents are equal and interchangeable. Metric conversions are described in Appendix B.

1.4 AVAILABILITY OF TEST RESULTS

The manufacturer shall prepare a report as outlined below:

	Outline of Report Requirements.
Par. 5.1	Manufacturers Make-Up Procedure.
Par 5.1.1	Report per ASTM D2992 and Par. 5.1.1.
Par. 5.1.2	Report per ASTM D2992 and Par. 5.1.2.
Par 5.1.3	Report per ASTM D1599 and Par 5.1.3.
Par. 5.1.4	Report per ASTM D1599 and Par. 5.1.4.
Par 5.4.1	Report per ASTM D2992 and calculation of requalification LTHS.
Par. 8.1.c	Report per manufacturers written test procedure.
Par. 8.1.d	Report per Appendix D.
Par. 8.1.e	Report per Appendix D.
Par. 8.1.f	Report per Appendix F.
Par. 8.1.g	Report per ASTM D2105.
Par. 8.1.h	Report per ASTM D1599.
Par. 8.2	For each qualified pipe, include a table showing inside diameter, minimum reinforced wall thickness, and hoop stress rated pressure.
Appendix A	For all qualified components product characteristics outlined in Appendix A.
Manufacturer's Table	A table listing all qualified components by size and pressure rating.

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 Specification 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 Specification 15HR the manufacturer shall complete the report described above. This copy must 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 tests results for a minimum of 5 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 Specification 15HR; such reports, articles, or advertisements must be worded in a fashion which will not imply that the American Petroleum Institute either recommends or disapproves use of the subject components.

2 References

2.1 GENERAL

This specification includes by reference, either in total or in part, the most current issue of the following standards, unless a specific edition is listed.

API	
Std 5B	*Specification for Threading, Gaging, and Threading, Gaging and Thread Inspection of Casing, Tubing and Line Pipe Threads*
RP 5B1	*Recommended Practice for Gaging and Inspection of Casing, Tubing and Line Pipe Threads*
Spec 15LR	*Specification for Low Pressure Fiberglass Linepipe*
RP 15TL4	*Recommended Practice for Care and Use of Fiberglass Tubulars*
ANSI[1]	
B16.5	*Pipe Flanges and Flanged Fittings, 1996*
ASTM[2]	
D1598	*Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure. 1997*
D1599	*Test Method for Short-Time, Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings, 1995*
D2105	*Test Method for Longitudinal Tensile Properties of Reinforced Thermosetting Resin Pipe and Tube, 1997*
D2143	*Test Method for Cyclic Pressure Strength of Reinforced, Thermosetting Plastic Pipe, 1994*
D2992	*Method for Obtaining Hydrostatic Design Basis for Reinforced Thermosetting Resin Pipe and Fittings, 1991*
D3567	*Method for Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings, 1991*

2.2 REQUIREMENTS

Requirements of other standards included by reference in this specification are essential to the safety and interchangeability of the equipment produced.

2.3 EQUIVALENT STANDARDS

Other nationally or internationally recognized standards shall be submitted to and approved by API for inclusion in this specification prior to use as equivalent standards.

3 Glossary (Definitions, Abbreviations)

3.1 DEFINITIONS

3.1.1 acceptance criteria: Defined limits placed on characteristics of materials, products, or services.

3.1.2 adapters: Appurtenances that allow connecting components with different joining systems.

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

3.1.4 date of manufacture: Date of cure.

3.1.5 fiberglass: A generic term for glass fiber reinforced thermosetting resins.

3.1.6 fittings: Tees, 90s and 45s.

3.1.7 flanges: Face flanges with bolt circle and face dimensions per ANSI B16.5.

3.1.8 may: Used to indicate that a provision is optional within this specification.

3.1.9 pi tape: A tape used to measure circumference.

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

3.1.11 records: Retrievable information.

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

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

3.1.14 shall: Used to indicate that a provision is mandatory within this specification.

3.1.15 should: Used to indicate that a provision is not mandatory but recommended as good industry practice within this specification.

3.1.16 Specification 15HR Standard Pressure Rating: The manufacturer's pressure rating determined in accordance with API Specification 15HR.

3.1.17 visual examination: Examination of parts and equipment for visible defects in material and workmanship.

[1]American National Standards Institute, 11 West 42nd Street, New York, New York 10036.
[2]American Society for Testing and Minerals, 100 Barr Harbor Drive, West Conshohocken, Pennslyvania 19428 2959.

3.2 ABBREVIATIONS

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
DSC	Differential Scanning Calorimetry
LCL	95% Lower Confidence Limit
LTHS	Long-Term Hydrostatic Strength

4 Purchasing Guidelines

4.1 GENERAL

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

4.1.1 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 particular needs and requirements, as well as information on the environment, to the manufacturer for his use in designing and producing pipe or component.

4.1.2 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.

Appendix H provides a format to document service conditions and requirements for ordering high pressure fiberglass components.

4.2 PRESSURE RATINGS

It is recommended that the pipe be purchased by pressure rating. The API Standard Pressure Ratings are from 500 lbf/in.^{2} gauge through 5,000 lbf/in.^{2} gauge in 250 lbf/in.^{2} gauge increments. The user should purchase pipe suitable for the specific service conditions.

4.3 COMPONENTS

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

5 Design

5.1 PERFORMANCE REQUIREMENTS

5.1.1 Pipe and Prime Connection

The published Specification 15HR Standard Pressure Rating shall be determined by the following method:

ASTM Standard Method D 2992 Procedure B with free ends shall be performed at 150°F or higher. Each specimen that fails beyond 6,000 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:

10 – 1,000 hours	at least 4
1,000 – 6,000 hours	at least 3
Beyond 6,000 hours	at least 6
Total Hours	at least 18

The test sample shall be a size no smaller than 2 in. nominal diameter, with an outside diameter to reinforced wall thickness ratio of 10 or less for scaling to be unlimited. If an outside diameter to reinforced wall thickness ratio of greater than 10 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 D 2992 test started after September 15, 1988, shall have DSC (Differential Scanning Calorimetry) data on each sample in accordance with Appendix C.

The published Specification 15H Standard Pressure Rating shall be calculated by the following equations and rounded down to the nearest integer multiple of 250 lbf/in.^{2}:

$$P_r = S_s \cdot S_f \cdot \frac{R_0^2 - R_i^2}{R_0^2 + R_i^2} \qquad 1$$

Note: Equation 1 is applicable only when the OD/t ratio is 10 or less.

where

P_r = Specification 15HR Standard Pressure Rating, lbf/in.^{2} gauge,

S_s = 95% Lower Confidence Limit (LCL) of the Long-Term Hydrostatic Strength (LTHS) @ 20 years per ASTM D 2992 Procedure B @ 150°F or higher lbf/in.^{2},

S_f = 0.67 service (design) factor (See Appendix G.),

R_o = radius of the pipe at the outside of the minimum reinforced wall thickness inches,

R_i = radius of the pipe at the inside of the minimum reinforced wall thickness inches.

$$P_r = \frac{2S_s t}{D} \qquad 2$$

where

P_r = Specification 15HR Standard Pressure Rating, lbf/in.^{2} gauge,

S_s = 95% Lower Confidence Limit (LCL) of the Long-Term Hydrostatic Strength (LTHS) @ 20

years per ASTM D 2992 Procedure B @ 150°F or higher, lbf/in.^{2},

t = minimum reinforced wall thickness, in.,

D = average diameter (OD-t) or (ID+t), in.

where

ID is the inner diameter of the reinforced wall, and OD is the outer diameter of the reinforced wall.

Scaling based on the LCL shall be done using Equation 1 or 2.

If only one regression test as defined above is conducted, the Specification 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 Specification 15HR Standard Pressure Rating shall be at 150°F. This rating shall be based on data at 150°F if available, otherwise, this rating shall be interpolated from data above and below 150°F.
3. The proof test pressure shall be based on the Specification 15HR Standard Pressure Rating.

5.1.2 Fittings

a. Test the highest anticipated pressure class in the four inch size and its pipe and prime connection.
b. Test temperature, 150°F or higher.
c. Pressure test 6 fittings of each type (90° elbow, 45° elbow, tee). 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 makeup procedure. Thread dimensions and DSC T_g (per Appendix C) shall be recorded for each fitting.
e. The end caps shall be unrestrained and there shall be at least 12 in. 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)
10 to 100
100 to 1000
greater than 2000

f. Calculate a pressure regression line per 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.

5.1.3 Fitting Short-Term Failure Pressure

a. Test two untested fittings of the same size, construction and pressure class as tested in 5.1.2. Use the assembly procedure of 5.1.2 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).
c. Establish the burst ratio the same as in 5.1.4. Specification 15HR Standard Pressure Rating. Other sizes and pressure classes of component shall equal or exceed the ratios established in 5.1.4.

5.1.4 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 D 1599 (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 reinforced wall thickness shall be recorded. Tests shall be conducted at ambient temperature. The ratio (R_4) for 4 in. components is defined as follows:

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

where

R_4 = ratio of average failure pressure and Specification 15HR Standard Pressure Rating for 4 in. component,

P_{b4} = failure pressure (ASTM D 1599, free end) of untested 4 in. component qualified in accordance with 5.1.4,

P_{r4} = Specification 15HR Standard Pressure Rating for the 4 in. component qualified in accordance with 5.1.3.

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

$$P_r \leq \frac{P_b}{R_4}$$

P_r = Specification 15HR Standard Pressure Rating for component.

P_b = Failure pressure of component (ASTM D 1599, free end).

5.2 DIMENSIONS

5.2.1 Length

Full length joints of pipe shall be in lengths according to the following schedule measured to the nearest 1 ft.

Length 1	Length 2	Length 3
15 to 21 ft	21 to 34 ft	34 or more ft

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.

5.2.2 Dimensional Tolerances

Tolerances on inside diameter, total wall thickness, minimum reinforced wall thickness, and outside diameter are defined in Table 1.

Table 1—Tolerance on Dimensions

	Tolerance
Total Wall Thickness	+22.5%
	-0%
Reinforced Wall Thickness	+22,5%
	-0%

Outside Diameter, D, is governed by the inside diameter and wall thickness

Nominal Sizes (in.)	Minimum Inside Diameter (in.)
1	0.90
1 1/2	1.350
2	1.870
2 1/2	2.345
3	2.720
3 1/2	3.300
4	3.690
5	4.300
6	5.300
8	7.625
10	8.800

5.2.3 Flanges

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

5.3 THREADED END CONNECTIONS

5.3.1 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.

5.3.2 Standard Thread Design

a. Pipe threads shall conform to API Standard 5B *Threading, Gaging and Thread Inspection of Casing, Tubing and Line Pipe*.

Threads, with the thread dimensions in Table 2.6a, External Upset Tubing Long Thread Dimension for Reinforced Thermosetting Resin Tubing, and Table 2.3, Casing Long-Thread Dimensions.

For the purpose of this specification, lengths L_2 and L_4, in API Standard 5B, Table 2.6a and Table 2.3 shall be minimum dimensions. Any extra threads shall be added to the tube side of the thread.

b. Thread tolerances will be defined in API Standard 5B, Table 2.10, *Tolerances in Linepipe Thread and Casing and Tubing Round Thread Dimensions*.

c. Round threads shall have a fully rounded thread root and crest as conceptually illustrated in API Standard 5B, Figure 2.4, *Casing and Tubing Round Thread Form*. For 8 round threads, thread root radius shall be 0.017 in. ± 0.0015 in. Thread crest radius shall be 0.020 in. ± 0.0015 in. For 10 round threads, thread root radius shall be 0.014 in. ± 0.0015 in. Thread crest radius shall be 0.017 in. ± 0.0015 in.

d. Threads for the 10-inch size only shall be per API Standard 5B, Table 6, *Casing Short–Thread Dimensions*.

5.3.3 Alternate Pipe Connections

Alternate 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.

5.3.4 Gaging Practice for Threads and Pipe Connections

a. Gaging Practice for Standard Threads

The manufacturer shall own or have access to master gages for each size of thread produced on products conforming to this specification. The manufacturer shall also own or have access to working gages conforming to gaging practices and gage specifications in API Standard 5B for use in gaging the product threads, and shall maintain all working gages in such condition as to ensure that product threads gaged as required

in API Standard 5B are acceptable under that specification except as noted in 5.3.2 of this specification. Thread gaging procedures shall be in accordance with API RP 5B1.

b. Gaging Practice for Alternate Pipe Connections

The manufacturer shall own or have access to gages and working gages.

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

5.4 REQUALIFICATION

5.4.1 Requalification Tests for Pipe and Prime Connection

Changes as described in Appendix A for previously qualified systems shall require the following minimum tests:

The long-term static LTHS shall be verified at 150°F, or higher temperature if so rated, after any changes as described in Appendix A by conducting the abridged ASTM D 2992 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.

Test samples shall be a size no smaller than 2 in. nominal diameter. The same outside diameter to reinforced wall ratio (D/t) constraints as in 5.1.1 shall apply for requalification.

5.4.2 Requalification Tests for Other Components

The requalification tests of 5.1.2, 5.1.3 and 5.1.4 shall be repeated after any change as described in Appendix A.

6 Process of Manufacture and Material

6.1 PROCESS OF MANUFACTURE

Pipe furnished to this specification shall be produced by filament winding (FW) or centrifugal casting (CC) methods.

Components furnished to this specification shall be produced by compression molding (CM), centrifugal casting (CC), filament winding (FW) or resin transfer molding (RTM) methods.

6.2 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.

Note: 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.

7 Quality Program

7.1 QUALITY MANUAL

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

7.2 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 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 5 years from the date the manufacturing of the product is discontinued.

7.3 QUALITY CONTROL EQUIPMENT

7.3.1 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.

7.3.2 Dimensional Measuring Equipment

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

7.3.3 Pressure Measuring Devices

a. Test pressure measuring devices shall be either pressure gages 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 6 months to maintain the required accuracy or calibrated when subjected to unusual or severe conditions, such as, would render its accuracy questionable.

7.4 QUALITY CONTROL TESTS

7.4.1 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. For every 50th joint, test pressure shall be maintained for a minimum of 10 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.

7.4.2 Degree of Cure

Degree of cure shall be determined by differential scanning calorimetry (DSC) according to Appendix C at a minimum frequency of once per shift for each resin system used at each manufacturer's facility. DSC tests, in accordance with Appendix C, shall also be conducted on fittings at a frequency of one per 100 units irrespective of size, type or pressure rating. The *Tg* shall not be more than 5°C below the minimum values measured in 5.1.1 and 5.1.4. This may be the same fitting used in 7.4.3.

7.4.3 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 8.1.h and greater than 85% of the minimum failure pressure of that component in the testing done in accordance with 5.1.2. 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 5,000 ft 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.

7.4.4 Visual Inspection

All pipe furnished to this specification shall meet the visual inspection limits in Table 2.

7.4.5 Retest

If any component fails to conform to the specified requirements 7.4.2 and 7.4.3, 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.

7.4.6 Wall Thickness

Total wall thickness shall be determined by caliper, eddy current thickness gage, or pi tape on the outside diameter and calculate thickness based on measured inside diameter on every joint away from the upset. Reinforced wall thickness shall be determined by ASTM D 3567 once every lot. Total and reinforced wall tolerances shall be as specified in Table 1.

7.4.7 Thread Gaging

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

7.5 INSPECTION AND REJECTION

When stated on the purchase order, the provisions of Appendix E, Purchaser Inspection, shall apply.

7.6 QUALITY CONTROL RECORDS REQUIREMENTS

7.6.1 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.

7.6.2 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 shall be retained by the manufacturer for a minimum of 5 years following the date of manufacture.
c. All quality control records required by this specification shall be signed and dated.

7.6.3 Records to be Maintained by Manufacturer

Test results in accordance with 7.4.

Table 2—Visual 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 square in. 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. deep, no limit on number.
Resin Drip	Resin protrusion.	Maximum 1/8 in. high, no limit on number.
Restriction	Any restriction: paste, epoxy or wax, lump, foreign matter in I.D. 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., 1 permitted per thread. Maximum size 1/16 in., 10 permitted per thread.
Chips	Areas where over 10% of thread height is removed.	Maximum 3/8 in. 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. 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. variation in end.
Finish	Finish cut end.	No sharp edges. No exposed loose fiber. No protrusions. No impact areas.

8 Published Values

8.1 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.
b. The LTHS and LCL as described in 5.1.1.
c. A value for the thermal coefficient of expansion in the axial direction over the ranges from 32°F to 73.4°F, and from 73.4°F 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 and at the maximum rated temperature in accordance with Appendix D.
e. Poisson's ratio for a hoop tensile load and the resulting axial contraction at 73.4°F and at the maximum rated temperature in accordance with Appendix D.
f. Poisson's ratio for an axial tensile load and the resulting hoop contraction at 73.4°F and at the maximum rated temperature in accordance with Appendix F.
g. Axial tensile modulus of elasticity at 73.4°F and at the maximum rated temperature in accordance with ASTM D 2105.
h. Short-term hydraulic failure pressure of pipe across the connection at 73.4°F and at the maximum rated temperature in accordance with ASTM D1599 (free end).

8.2 PUBLISHED DIMENSIONS

Manufacturers shall publish the following information for each qualified products:

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.

9 Equipment Marking

9.1 METHODS

Components manufactured in conformance with this specification shall be marked by the manufacturer as specified in 9.2. (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 day of manufacture. Markings shall be applied on the pipe from one to three feet from the box connection.

9.2 MARKING REQUIREMENTS

Components shall be marked with the following:

a. Manufacturer's name or mark.
b. "15HR"[3] (and A.C. notation, if applicable).
c. Nominal size.
d. Unique identification number.
e. Specification 15HR Standard Pressure Rating.
f. Date of manufacture.

10 Handling, Packaging, Storing, and Shipping Requirements

10.1 COUPLING MAKEUP 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 makeup procedure shall be that recommended by the manufacturer.

10.2 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.

10.3 FLANGE FACE PROTECTORS

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

10.4 PACKAGING, SHIPPING AND HANDLING REQUIREMENTS

Manufacturers shall comply with Sections 1 and 2 of API RP 15TL4.

[3]Users of the specification should note that there is no longer a requirement for marking a product with the API monogram. The American Petroleum Institute continues to license use of the monogram on products covered by this specification but it is administered by the staff of the Institute separately from the specification. The policy describing licensing and use of the monogram is contained in Appendix I herein. No other use of the monogram is permitted. Non-licensees may mark products in conformance with Section 9 and Licensees may mark products in conformance with Appendix I.

APPENDIX A—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 must 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 Section 5.4.

A.1 Reinforcement

Manufacturer
Production designation to include reference to:
- Mean filament diameter
- Finish (sizing) type and amount
- Type (single or multiple end)
- Chemical composition of fiber
- Yield

A.2 Resin Matrix

Manufacturer
Product designation

A.3 Curing Agent

Manufacturer
Product designation

A.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)

A.5 Adhesives

Manufacturer
Product designation

A.6 Thread Molding Compounds

Manufacturer
Product designation

A.7 Thread Sealing Compounds

Manufacturer
Product designation
Generic type
Solids weight percent, size distribution, material and shape

A.8 Joint Sealing Element

Manufacturer
Product designation
Shore "A" durometer hardness
Seal dimensions

A.9 Manufacturing[4]

Cure temperature and time schedule
Winding angle
Stacking sequence
Percent reinforcement in each direction
Glass transition temperature as determined in Appendix C
Thread dimensions as specified in Section 5.3

A.10 Report

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

[4]Recognize these parameters may be different for each size and rating.

APPENDIX B—METRIC CONVERSIONS

US Customary units are in all cases preferential and shall be the standard in this specification.

Length	1 inch (in.)	25.4 millimeters (mm) exactly
Pressure	1 pound per square inch ($lbf/in.^2$)	0.06894757 Bar
	Note: 1 Bar = 100 kiloPascals (kPa)	
Strength or Stress	1 pound per square inch ($lbf/in.^2$)	0.006894757 Megapascals (MPa)
Impact Energy	1 foot–pound (ft-lb)	1.3558181 Joules (J)
Torque	1 foot–pound (ft-lb)	1.3558181 Newton-meters (N m)
Temperature	The following formula was used to convert degrees Fahrenheit (°F) to degrees Celsius (°C): $°C = 5/9 (F - 32)$	
Mass	1 pound (lb)	0.4535924 kilograms (kg)

APPENDIX C—TEST METHOD FOR DETERMINATION OF DEGREE OF CURE BY DIFFERENTIAL SCANNING CALORIMETRY (DSC)

C.1 Scope

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

C.2 Definition

Glass transition temperature, *Tg*, is defined as the midpoint of the inflection temperature of the DSC curve (heat flow vs. temperature) for the first scan.

C.3 Apparatus

Differential scanning calorimeter (DSC). The DSC equipment shall be calibrated in accordance to the DSC manufacturer at a frequency specified by the DSC manufacturer or at 6-month intervals, whichever is shorter.

C.4 Test Specimens

C.4.1 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.

C.4.2 LOCATION

For any given tubular product, a sample shall be taken 0 - 10 mils from the outer surface for internally cured products, or 0-10 mils 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.

C.5 Procedure

C.5.1 Maximum heating rate is 40°C/min.

C.5.2 Run the scan from room temperature to at least 30°C above the expected glass transition temperature and no more than 250°C.

C.5.3 Obtain the *Tg*.

C.6 Report

The report shall include the following items.

C.6.1 Complete identification of the specimens including material, Manufacturer's name, and lot number.

C.6.2 Pipe dimensions, including nominal size, minimum reinforced wall thickness, and average outside diameter.

Unreinforced thicknesses (i.e., liner) shall also be reported.

C.6.3 Number of specimens tested and where the specimens were taken from the pipe.

C.6.4 Heat-up rate for DSC temperature scans.

C.6.5 Record the inflection value for the first scan as the glass transition temperature, *Tg*.

C.6.6 Date of test.

C.6.7 Test laboratory and supervisor of tests.

APPENDIX D—DETERMINATION OF THE HOOP TENSILE MODULUS AND POISSON'S RATIO

D.1 Scope

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

D.2 Definitions

D.2.1 Hoop tensile modulus is defined as the hoop tensile stress divided by the hoop strain under the condition of uniaxial hoop tensile stress.

D.2.2 Poisson's ratio is the ratio of axial strain to hoop strain as measured by strain gages with the tube pressurized to its rated pressure in accordance with this procedure.

D.3 Apparatus

D.3.1 A pressure source with a calibrated pressure measuring device.

D.3.2 Strain gage monitoring equipment and gages.

D.3.3 A test fixture as shown in Figure 1.

D.4 Test Specimens

D.4.1 SIZE

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

D.4.2 NUMBER OF SPECIMENS

Three specimens shall be tested for each pipe being evaluated.

D.4.3 The samples selected shall be standard production pipe.

D.5 Test Procedure

D.5.1 Apply two strain gages to each specimen as shown in Figure 1. One strain gage shall be oriented to measure strain in the axial direction. The other strain gage shall be oriented to measure strain in the hoop direction. Standard strain gaging practices shall be followed.

D.5.2 Insert the test fixtures into the test specimen as shown in Figure 1.

D.5.3 Zero the strain gages.

D.5.4 Pressurize the specimen to its rated internal pressure.

D.5.5 Record the hoop and axial strain.

D.6

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

D.6.1 Determine the hoop stress by the following formula:

$$h = P\frac{R_0^2 + R_i^2}{R_0^2 - R_i^2}$$

where

h = hoop stress, lbf/in.^{2},

P = internal pressure, lbf/in.^{2},

R_i = the inside radius of the structural wall, inches,

R_o = the outside radius of the structural wall, inches.

The inside diameter and structural wall thickness are determined by ASTM D 3567.

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

D.7 Report

The report shall include the following items.

D.7.1 Complete identification of the test samples including material and manufacturer's name.

D.7.2 Pipe dimensions, including nominal size, reinforced wall thickness, inside diameter and length.

D.7.3 The applied pressure.

D.7.4 The measured hoop and axial strain, and the calculated hoop stress, for each sample.

D.7.5 The mean hoop tensile modulus and Poisson's ratio.

D.7.6 The test temperature.

D.7.7 Start date and completion of tests.

D.7.8 Test laboratory and supervisor of tests.

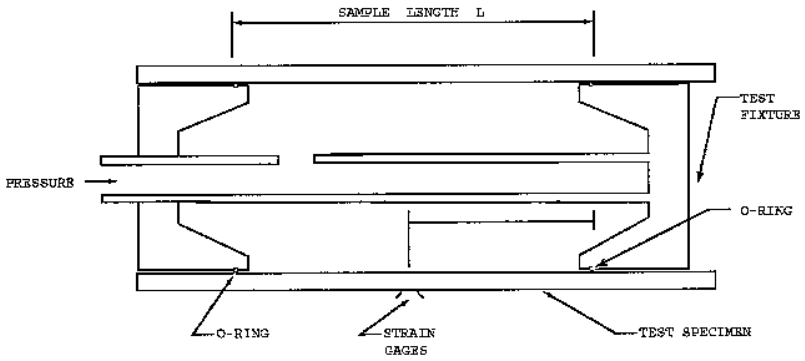

Figure 1—Typical Test Setup to Determine Hoop Tensile and Poisson Ratio

APPENDIX E—PURCHASER INSPECTION

E.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.

E.2 Plant Access

The inspector representing the purchaser shall have unrestricted access at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which will concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the pipe is being manufactured in accordance with this specification. 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.

E.3 Compliance

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

E.4 Rejection

Unless otherwise provided, material which shows defects on inspection or subsequent to acceptance at the manufacturer's works, or which 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 which 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.

APPENDIX F—DETERMINATION OF THE AXIAL TENSILE POISSON'S RATIO

F.1 Scope

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

F.2 Definitions

F.2.1 Poisson's ratio is the ratio of hoop strain to axial strain as measured by strain gages with the tube loaded to the axial load that would be produced at the rated pressure of the sample.

F.3 Apparatus

F.3.1 A testing machine and grips that meets the requirements set forth in Sections 5.1, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.1.5, and 5.1.6 of ASTM D 2105-85.

F.3.2 Strain gage monitoring equipment and gages.

F.4 Test Specimens

F.4.1 SIZE

The sample length shall be minimum of 18 in. between grips.

F.4.2 NUMBER OF SPECIMENS

Three specimens shall be tested for each pipe being evaluated.

F.4.3 The sample selected shall be standard production pipe.

F.5 Test Procedure

F.5.1 Apply two strain gages to each specimen as shown in Figure D.1 of Appendix D. One strain gage shall be oriented to measure strain in the axial direction. The other strain gage shall be oriented to measure strain in the hoop direction. Standard strain gaging practices shall be followed.

F.5.2 Insert the test sample into the testing machine per section 9.2 of ASTM D 2105-85.

F.5.3 Zero the strain gages.

F.5.4 Set the speed of testing per Section 9.3.1 or 9.3.2 of ASTM D 2105-85.

F.5.5 Load the sample up to the axial load that would be produced at the rated pressure of the sample.

Note: If the correct equipment is available, the strains and loads can be recorded continuously, or per Section 9.4 of ASTM D 2105-85, 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 D 2105-85, but use the axial tensile strain gage as the extension indicator.

F.6

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

F.7 Report

The report shall include the following items.

F.7.1 Complete identification of the test samples including material and manufacturer's name.

F.7.2 Pipe dimensions, including nominal size, reinforced wall thickness, inside diameter and length.

F.7.3 The applied load.

F.7.4 The measured hoop and axial strain at the applied load for each sample.

F.7.5 The mean axial tensile Poisson's ratio.

F.7.6 The test temperature.

F.7.7 Start date and completion of tests.

F.7.8 Test laboratory and supervisor of tests.

APPENDIX G—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, Sf in Equation 1, will be the product of the individual service factors thus permitting adjustment of the Specification 15HR Standard Pressure Rating for specific applications having other than the defined Standard Conditions.

$$S_f = SF^C \times SF^E \times SF^L \times SF^T \times SF^A$$

where

S_f = overall service (design) factor (used in Equation 1),

SF^C = Service Factor for cyclic pressure variations, which will be based on results of a test program currently being defined,

SF^E = Service Factor for Environment, which will be based on a test program being evaluated,

SF^L = Service Factor for design life, which will be defined as follows:

$$SF^L = \frac{\text{LCL @ Design Life \& 150°F}}{\text{LCL @ 20 years \& 150°F}}$$

LCL at a higher temperature may be substituted for LCL @ 150°F,

SF^T = Service Factor for Temperature, which will be defined as follows:

$$SF^T = \frac{\text{LCL @ Design Temperature \& 20 years}}{\text{LCL @ 150 °F \& 20 years}}$$

LCL at a higher temperature may be substituted for LCL @ 150°F.

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 = Service Factor for additional axial loads (less than or equal to 1.0), which will be defined as follows:

$$SF^A = \frac{sAP - sAA}{sAP}$$

where

sAP = axial stress due to the Specification 15HR pressure rating

$$= \frac{P_R R_i}{(R_o - R_i)}$$

sAA = axial stress due to additional axial loads, for example bending a pipe to a certain radius of curvature, where sAA would be calculated as shown,

$$sAA = \frac{E_A R_o}{R_c}$$

where

E_A = the axial modulus of elasticity, lbf/in.^{2},

R_c = radius of curvature, inches.

APPENDIX H—DATA SHEET

API Monogram required? Yes_____ No_____

Project(s) and location(s):_____

Maximum operating pressure:_____

Test Pressure:_____

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 which 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:_____

_____

Technical contact in buyer's organization: _____Phone: _____

APPENDIX I—USE OF API MONOGRAM

I.1 Reporting Requirements for API Licensees

Before a license to use the API monogram is granted, the manufacturer shall complete the report described in 1.4.

I.2 Marking Requirements for API Licensees

Components shall be marked with the following:

a. Manufacturer's name or mark.
b. API monogram (and A.C. notation, if applicable).
c. Nominal size.
d. Unique identification number.
e. Specification 15HR Standard Pressure Rating.
f. Date of manufacture.
g. API license number.

Additional copies are available through Global Engineering Documents at (800) 854-7179 or (303) 397-7956

Information about API Publications, Programs and Services is available on the World Wide Web at: http://www.api.org

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005-4070
202-682-8000

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