

Specification for Low Pressure Fiberglass Line Pipe

API SPECIFICATION 15LR
SEVENTH EDITION, AUGUST 2001

REAFFIRMED, OCTOBER 2013



AMERICAN PETROLEUM INSTITUTE

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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 low 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 F.
- g. This Standard shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.
- h. Suggested revisions are invited and should be submitted to the standardization manager, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

Attention Users of this Publication: 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. Since the document was significantly re-formatted from the previous edition, no attempt was made to indicate the location of changes with bar notations.

CONTENTS

	Page
1 SCOPE	1
1.1 Coverage	1
1.2 Unit Conversion	1
1.3 Suggestions for Ordering API Low Pressure Fiberglass Line Pipe and Fittings	1
2 REFERENCES	1
2.1 References Standards	1
2.2 Requirements	2
2.3 Equivalent Standards	2
3 PROCESS OF MANUFACTURE AND MATERIALS	2
3.1 Process of Manufacture	2
3.2 Material	2
4 MATERIAL PROPERTIES AND TESTS	2
4.1 General	2
4.2 Degree of Cure	2
4.3 Methods of Material Analysis	2
4.4 Frequency of Tests	2
5 PHYSICAL PROPERTIES AND TESTS	2
5.1 Physical Properties	2
5.2 Frequency of Tests	3
5.3 Minimum Properties	3
5.4 Service Factors	3
5.5 Pressure Rating	3
5.6 Qualification Requirements for Fittings	4
5.7 Qualification Tests for Fittings, Couplings, and Connections	4
5.8 Requalification Tests for Fittings, Couplings, Connections and Adhesives	5
6 QUALITY CONTROL TESTS	5
6.1 Pipe	5
6.2 Fittings—Mill Pressure Tests	5
7 DIMENSIONS AND LENGTHS	5
7.1 Pipe	5
7.2 Fittings Dimensions	6
8 PIPE ENDS, CONNECTIONS, END PROTECTION, AND WORKMANSHIP	6
8.1 Pipe Ends	6
8.2 Product Drawings	8
8.3 Workmanship	8
8.4 Repair of Surface Imperfections	8
8.5 End Protection	8
8.6 Purchaser Inspection	9
9 MARKING	9
9.1 Methods	9
9.2 Marking Requirements	9

	Page
APPENDIX A METHOD OF TEST FOR GLASS-RESIN RATIO OF FIBERGLASS PIPE.....	11
APPENDIX B METHOD OF TEST FOR THE DETERMINATION OF DEGREE OF CURE BY DIFFERENTIAL SCANNING CALORIMETRY (DSC)	13
APPENDIX C METHOD OF TEST FOR IMPACT RESISTANCE OF FIBERGLASS PIPE.....	15
APPENDIX D SAMPLING PLAN BASIS: 0.75% AOQL (AVERAGE OUTGOING QUALITY LIMIT)	17
APPENDIX E PRODUCT CHARACTERISTICS	19
APPENDIX F MARKING REQUIREMENTS FOR MONOGRAM LICENSEES ...	21
APPENDIX G METRIC CONVERSIONS	23
APPENDIX H PURCHASER INSPECTION	25

Tables

1	Dimensions—2 in. through 6 in. Sizes	6
2	Dimensions—8 in. and Larger Sizes	6
3	Dimensional Tolerances	6
4	Thread Sizes	7
5	Spigot Dimensions for Tapered Ends Adhesive Bonded Joints	8
6	Socket Dimensions for Adhesive Bonded Joints Using Non-Tapered Pipe Ends ..	9
7	Visual Standards	10
E.1	Reporting Format for API Spec 15LR Appendix E Product Characteristics.....	20

Specification for Low Pressure Fiberglass Line Pipe and Fittings

1 Scope

1.1 COVERAGE

This specification covers filament wound (FW) and centrifugally cast (CC) fiberglass line pipe and fittings for pipe in diameters up to and including 24 in. in diameter and up to and including 1000 psig cyclic operating pressures. In addition, at the manufacturer's option, the pipe may also be rated for static operating pressures up to 1000 psig. It is recommended that the pipe and fittings be purchased by cyclic pressure rating. The standard pressure ratings range from 150 psig to 300 psig in 50 psig increments, and from 300 psig to 1000 psig in 100 psig increments, based on either cyclic pressure (ref. 5.5.1) or static pressure (ref. 5.5.2). Quality control tests, hydrostatic mill tests, dimensions, weights, material properties, physical properties, and minimum performance requirements are included.

1.2 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 G.

1.3 SUGGESTIONS FOR ORDERING API LOW PRESSURE FIBERGLASS LINE PIPE AND FITTINGS

1.3.1 In placing orders for line pipe to be manufactured in accordance with API Specification 15LR, the purchaser may specify the following on the purchase order:

Specification	API Specification 15LR
Quantity	
Pressure Rating	Par. 1.1
Process of Manufacture	Par. 3.1
Resin System	Par. 3.2
Nominal Size or Outside Diameter	Table 1 and 2
Length	Par. 7.1.2
Pipe Ends	Par. 8.1
Delivery Date and Shipping Instructions	

1.3.2 Attention is called to the following paragraphs which may require agreement between the purchaser and the manufacturer:

Service Factors	Par 5.4
Disposition of Rejected Product	Appendix H, Par. H.4

1.3.3 The purchaser should also state on the purchase order his requirements concerning the following stipulations which are optional with the purchaser:

Degree of Cure	Par. 4.4
Physical Properties	Par. 5.1
Static Pressure Rating	Par. 5.5.2
Pipe Drawings	Par. 8.2
Purchaser Inspection	Par. 8.6

2 References

2.1 REFERENCES STANDARDS

This specification includes by reference, either in total or in part, the following API, industry and government standards. Where a specific edition of a standard is referenced, it was the latest edition available for review by the API Subcommittee on Fiberglass and Plastic Tubulars at the time this edition was printed. Subsequent revisions are subject to API subcommittee review prior to acceptance as a referenced standard to this specification.

API	
Std 5B	<i>Specification for Threading, Gaging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads, Latest Edition</i>
RP 5B1	<i>Recommended Practice for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads, Latest Edition</i>
ANSI ¹	
B16.5	<i>Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24, 1996</i>
ASTM ²	
C 582	<i>Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment, 1995</i>
D 1599	<i>Test Method for Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing and Fittings, 1995</i>
D 1694	<i>Specification for Threads for Reinforced Thermosetting Resin Pipe, 1995</i>
D 2105	<i>Test Method for Longitudinal Tensile Properties of Reinforced Thermosetting Plastic Pipe and Tube, 1990</i>

¹American National Standards Institute, 1430 Broadway, New York, New York 10018.

²ASTM, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428.

D 2143	<i>Test Method for Cyclic Pressure Strength of Reinforced, Thermosetting Plastic Pipe, 1994</i>
D 2412	<i>Test Method for External Loading Properties of Plastic Pipe by Parallel-Plate Loading, 1996</i>
D 2924	<i>Test Method for External Pressure Resistance of Reinforced Thermosetting Resin Pipe, 1993</i>
D 2925	<i>Test Method for Beam Deflection of Reinforced Thermosetting Plastic Pipe Under Full Bore Flow, 1995</i>
D 2992	<i>Procedure A and B; Method for Obtaining Hydrostatic Design Basis for Reinforced Thermosetting Resin Pipe and Fittings, 1991</i>
D 3567	<i>Method for Determining Dimensions of Reinforced Thermosetting Resin Pipe (RTRP) and Fittings, 1991</i>

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 Process of Manufacture and Materials

3.1 PROCESS OF MANUFACTURE

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

3.2 MATERIAL

The reinforced wall of pipe and fittings shall consist of thermosetting polymers reinforced with glass fibers. Acceptable polymers are epoxy resins, polyester resins, and vinyl ester resins. Couplings, connections, fittings, and adhesives shall meet the performance properties listed in 5.6 and 5.7 and shall be manufactured by a process and from materials compatible with the pipe system. They shall at least be equally resistant to the same fluids and environments as the pipe.

Note: (1) 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.

Note: (2.) Vinyl ester resins are defined in ASTM C 582.

4 Material Properties and Tests

4.1 GENERAL

Pipe and fittings furnished to this specification shall conform to the material requirements listed in 3.2.

4.2 DEGREE OF CURE

Degree of cure shall be determined by differential scanning calorimetry (DSC) according to Appendix B at a minimum frequency of once per shift for each resin system used at each manufacturer's facility. DSC tests, in accordance with Appendix B shall also be conducted on fittings at a frequency of one per 100 units of each size, type or pressure rating. The T_g shall not be more than 5°C below the minimum values measured in 5.2.2.1 and 5.7.4.

Manufacturers shall establish these values for each resin system used.

4.3 METHODS OF MATERIAL ANALYSIS

- Degree of cure (T_g) shall be determined following the procedure in Appendix B.
- Glass-resin ratios shall be determined following the procedures of Appendix A.

4.4 FREQUENCY OF TESTS

The manufacturer shall supply a report showing the degree of cure (T_g) per 4.2 and 4.3 at the frequency required by 6.1.4 for pipe. Samples for material analysis shall be taken from production runs.

5 Physical Properties and Tests

5.1 PHYSICAL PROPERTIES

Pipe furnished to this specification shall conform to physical property requirements in 5.3. Certain other properties do not have specified requirements but are nevertheless important in piping system design. The manufacturer shall perform the tests shown in 5.1a-5.1h as well as prepare all test reports in compliance with the applicable ASTM standard. These results shall be available upon request.

- Long-term hydrostatic strength cyclic at 150°F. ASTM D-2992 Procedure A.
Long-term hydrostatic strength static at 150°F or higher. Additionally, ASTM D-2992 Procedure B, at 150°F or higher when static rating is desired.
- Thermal Coefficient of Expansion. Per the manufacturer's written procedure.
- Axial Tensile Modulus of Elasticity. ASTM D-2105
- Parallel Plate Crush. SF at 5% deflection, ASTM D-2412, for products with OD/t ratios greater than 20.
- Ultimate Axial Tensile Strength. ASTM D-2105.

- f. Hydrostatic Collapse Pressure. ASTM D-2924.
- g. Short-time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings. ASTM D-1599.
- h. Beam bending modulus to determine pipe support spacing at 73.4°F and 150°F or maximum rated temperature when determined in accordance with ASTM D-2925.

5.2 FREQUENCY OF TESTS

Pipe furnished to this specification shall be tested by the manufacturer as follows:

5.2.1 The short-term test which shall be performed at ambient temperature at the minimum frequency of one per lot as defined in 6.1.2 shall be one of the following:

- a. Short-time hydrostatic failure pressure per ASTM D-1599.
- b. Cyclic Pressure Strength (short-term) per ASTM D-2143 for 750 cycles minimum.

5.2.2 One long-term cyclic hydrostatic regression test to determine the hydrostatic design basis (HDB) shall be performed at 150°F¹ on pipe manufactured by each process which contains no significant product characteristic differences such as listed in Appendix E. The tests shall be conducted as follows:

¹Note: When pipe is to be rated for temperatures higher than 150°F, the tests shall be conducted at the higher temperature.

5.2.2.1 Initial Tests

Long-term cyclic hydrostatic pressure tests shall be in compliance with ASTM D-2992 Procedure A. Any ASTM D 2992 test started after the effective date of this Seventh Edition of API Specification 15LR shall have DSC (Differential Scanning Calorimetry) data on each test sample in accordance with Appendix B.

5.2.2.2 Requalification Tests for Pipe and Prime Connection and Fittings

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

The long-term cyclic and static (if used) LTHS shall be verified at 150°F, or higher temperature if so rated, after any changes described in Appendix E by conducting the abridged tests required by Section 12 of ASTM D 2992 Procedure A and/or B (as required) (free-end). Test samples shall be assembled by the manufacturer's documented joining procedure. Test samples shall be a size no smaller than 2 in. nominal diameter. The same outside diameter to reinforced wall ratio (D/t) used in original qualification tests shall apply for requalification.

5.2.2.2.1 Requalification Tests for Other Components

The requalification tests of 5.7 shall be repeated after any change as described in Appendix A.

5.2.3 Impact Resistance

The impact resistance of 2 in. through 6 in. pipe with cyclic pressure ratings of 300 psi and less shall be tested initially following the procedure in Appendix C.

5.3 MINIMUM PROPERTIES

The minimum performance properties for tests specified in 5.2 are:

- a. Pipe shall hold for one minute a minimum hydrostatic pressure of 4.0 times its calculated cyclic operating pressure without failure when tested as per 5.2.1a.
- b. Pipe shall have a minimum short-term cyclic pressure life of 750 cycles when tested at a pressure equal to or greater than the lower confidence limit on the long-term cyclic hydrostatic pressure regression line when back calculated to 750 cycles.
- c. The hydrostatic design basis (HDB) extrapolated to 150 million cycles shall equal or exceed the manufacturer's published value current at the time of purchase.
- d. All 2 in. through 6 in. pipe with cyclic pressure ratings of 300 psig or less shall have impact resistance which exceeds the requirements of Appendix C.

Note: This test is not considered applicable for other pipe.

5.4 SERVICE FACTORS

The maximum recommended service factors are:

- a. 1.0 for the long-term cyclic HDB at 150×10^6 cycles.
- b. 0.67 for the 95% lower confidence limit (LCL) of the long-term hydrostatic strength (LTHS) at 20 years per ASTM D 2992 Procedure B at 150°F or higher.

5.5 PRESSURE RATING

5.5.1 Cyclic Pressure

The cyclic pressure rating for a pipe shall be calculated by using Equation 1 below and the hoop stress values determined by the long-term cyclic test listed in 5.2.2.1.

$$P_c = \frac{2S_c t}{D} \quad \text{Equation 1}$$

Where:

P_c = Specification 15LR standard internal cyclic pressure rating, psi

S_c = hoop stress = HDBc at 150×10^6 cycles x service factor, psi

t = minimum reinforced wall thickness, inches

D = average diameter (OD – t) or (ID + t), inches
Where: ID is the inner diameter of the reinforced wall, and OD is the outside diameter of the reinforced wall.

HDB_c = Hydrostatic Design Basis, cyclic, psi

5.5.2 Static Pressure

Additionally, a static pressure rating shall be determined by testing the pipe per ASTM D 2992 Procedure B at a temperature of 150°F or higher, if static pressure rating is to be used. The static pressure rating shall be calculated by using Equation 2:

$$P_s = 0.67 \frac{2S_s t}{D} \quad \text{Equation 2}$$

Where:

0.67 is a service factor

P_s = Static pressure rating, psi

S_s = 95% Lower Confidence Limit (LCL) of the Long-Term Hydrostatic Strength (LTHS) at 20 years per ASTM D 2992 Procedure B at 150°F or higher, psi

t = minimum reinforced wall thickness, inches

D = average diameter (OD – t) or (ID + t), inches
Where: O.D. is the inner diameter of the reinforced wall and O.D. is the outside diameter of the reinforced wall.

Note: Except as indicated above, all references to HDB in this specification refer to the cyclic HDB, and all piping shall be given pressure ratings on the cyclic basis.

5.5.3 Scaling

Pressure scaling

Pressure ratings for diameters and wall thicknesses other than those tested shall be determined as follows:

- For cyclic pressures use equation 1,
- For static pressures use equation 2.

Temperature scaling

If only one regression as defined above is conducted, the Specification 15LR Standard Pressure Rating shall be based

on the 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:

- Pressure ratings at temperatures between the test temperatures shall be based on a linear interpolation between the 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.
- The Specification 15LR 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.
- The proof test pressure shall be based on the Specification 15LR Standard Pressure Rating.

5.6 QUALIFICATION REQUIREMENTS FOR FITTINGS

Fittings, couplings, connections and adhesives shall meet the following performance requirements when tested with unrestrained ends in accordance with 5.7.

- Each component and its field-jointed configuration shall sustain a short-time hydrostatic pressure of at least four (4) times its cyclic rated pressure or three (3) times its static rated pressure for one minute without visible weeping or leakage.
- Each component shall meet or exceed the cyclic or static test requirements of 5.7.3.

5.7 QUALIFICATION TESTS FOR FITTINGS, COUPLINGS, AND CONNECTIONS

5.7.1 Test Specimens

Test specimens shall include at least one fitting in each configuration [for example, 45 degree and 90 degree elbow, tee, flange, coupling (includes integral coupling), etc.] joined to pipe sections at least 18 inches long or 2 diameters, whichever is longer, using the joining method, design, and adhesive intended for field assembly. Specimen diameters for test in each configuration shall include the maximum product size in each pressure class and each method of manufacture. In addition, smaller sizes in the pressure rating shall be tested as follows:

Product Size Range (inches)	Test Size (inches)
1, 1 1/2, 2, 2 1/2, 3	3
4, 5, 6	6
8, 10, 12	12
14, 16	16
18, 20, 24	24

In each range of size the manufacturer may elect at its option to test a smaller product size to qualify only the smaller size.

5.7.2 Short-Time Hydrostatic Qualification Pressure Tests

Short-time hydrostatic qualification pressure tests to determine compliance with 5.6a shall be performed with unrestrained ends at ambient temperature. The pressure shall be applied uniformly and continuously until the desired pressure is reached, in a time of no less than 60 seconds.

5.7.3 Cyclic or Static Pressure Test

- a. Using the cyclic test data or static test data and regression analysis as developed for the pipe, following ASTM D 2992, Procedure A or B, construct a regression line converting the stress (or strain) versus cycle data or stress (or strain) versus time data to pressure versus cycle or time data for pipe of the intended pressure class.
- b. For cyclic pressure tests, the gauge pressure at the peak pressure of the cycle shall be not less than 1 1/2 nor more than 2 times the pressure rating of the fitting. The cycle amplitude pressure shall be at least 80% of the selected peak pressure.
- c. For static pressure tests, the gage pressure shall be no less than 2 1/2 times and no more than 2 3/4 times the fitting static pressure rating.
- d. Test each component specimen as required above with unrestrained ends in accordance with Test Methods of ASTM D 2143 for cyclic tests and ASTM D 1598 for static tests, at a test temperature of 150°F. For components which are to be used at higher temperatures, the higher temperature shall be used.
- e. The number of cycles or hours to failure for the component must be no less than that predicted by the HDB line lower 95% prediction limits of the corresponding pipe.

5.7.4 Degree of Cure

All fittings, couplings and connections tested in accordance with 5.7 after the effective date of this Seventh Edition of API Spec 15LR shall have DSC data on each sample in accordance with Appendix B.

5.8 REQUALIFICATION TESTS FOR FITTINGS, COUPLINGS, CONNECTIONS AND ADHESIVES

The qualification tests of 5.7 shall be repeated after any change as described in Appendix E.

6 Quality Control Tests

6.1 PIPE

6.1.1 Mill Pressure Test

Pipe shall be tested following the sampling plan of Appendix D at a pressure of not less than 1.5 times the calculated cyclic pressure rating. All mill jointers shall be hydrostatically tested.

6.1.2 Lot of Pipe

A lot of pipe shall consist of 5,000 feet or fraction thereof of one size, wall thickness and grade in continuous production.

6.1.3 Pressure Test Frequency

The short-term cyclic pressure test or the short-time hydrostatic failure test per 5.2.1 shall be conducted at a minimum frequency of one test per lot.

6.1.4 Degree of Cure Test Frequency

The test for degree of cure (Tg) per 4.2 and 4.3 shall be conducted at a minimum frequency of one test per lot.

6.1.5 Retests

If any test specimen of the tests specifically mentioned in 5.2.1, 6.1 and 6.2 fails to conform to the specified requirements, the manufacturer may elect to reject the entire lot or make retests on two additional lengths from the same lot. If both of the retest specimens conform to the requirements, all of the lengths in the lot shall be accepted, except the length from which the initial specimen was taken. If one or both of the retest specimens fail to conform to the specified requirements, the manufacturer may elect to test individually the remaining lengths in the lot, in which case determinations are required only for the particular requirements with which the specimens failed to comply in the preceding test.

6.2 FITTINGS—MILL PRESSURE TESTS

All fittings except bushings and flanges shall be hydrotested or pneumatic tested at a pressure no less than 1.5 times its cyclic pressure rating.

7 Dimensions and Lengths

7.1 PIPE

7.1.1 Dimensions

Fiberglass pipe shall be furnished in sizes shown in Tables 1 and 2 as specified on the purchase order.

Table 1—Dimensions—2 in. through 6 in. Sizes

Nominal Size (inches)	Outside ⁽¹⁾ Dia. (inches)	Inside ⁽²⁾ Dia. (inches) Minimum
2	2.375	1.90
2 1/2	2.875	2.30
3	3.500	2.90
4	4.500	3.90
6	6.625	5.80

Notes:

- The outside diameters are applicable to:
 - All 300 psi cyclic pressure rated pipe.
 - All centrifugal cast pipe.
- When pipe with cyclic pressure rating greater than 300 psi is manufactured, the outside diameters are not specified and the controlling dimensions are the inside diameters listed in Table 1.

Table 2—Dimensions—8 in. and Larger Sizes

Nominal Size (inches)	Outside ⁽¹⁾ Dia. (inches)	Inside ⁽²⁾ Dia. (inches) Minimum
8	8.625	7.70
10	10.750	9.70
12	12.750	11.70
14		13.50
16		15.40
18		17.07
20		18.97
24		22.77

Notes:

- The outside diameters are applicable to:
 - All 150 psi cyclic pressure rated pipe.
 - All centrifugal cast pipe.
- When pipe with cyclic pressure rating greater than 150 psi is manufactured, the outside diameters are not specified and the controlling dimensions are the inside diameters listed in Table 2.

Table 3—Dimensional Tolerances

Nominal Size (Inches)	Outside Diameter (Inches)
1	+0.060, -0.018
1 1/2	+0.060, -0.018
2	+0.060, -0.018
2 1/2	+0.060, -0.018
3	+0.060, -0.018
4	+0.060, -0.018
5	+0.060, -0.018
6	+0.066, -0.028
8	+0.086, -0.040
10	+0.108, -0.048
12	+0.128, -0.056

Note: For tolerances for sizes larger than 12 in. refer to Table 2.

7.1.2 Length

Pipe shall be furnished in lengths according to the following schedule.

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

Jointers (two pieces coupled to make a standard length) may be furnished to a maximum of 5% of the order; but no length used in making a jointer shall be less than 5 ft. Two standard lengths joined to make one long length is not a jointer, but shall be mill hydro-tested at a pressure of 1.5 times the cyclic pressure rating.

7.1.3 Tolerances

Outside diameter of pipe furnished to this specification shall be within the tolerances listed in Table 3. The measurements shall be made in accordance with ASTM D 3567.

7.1.4 Wall Thickness

The pipe's minimum reinforced wall thickness shall not be less than that wall thickness calculated for its pressure class using 5.5.1 and when measured per ASTM D-3567.

7.2 FITTINGS DIMENSIONS

7.2.1 Flanges

The flange bolt circle, bolt hole diameter, and face dimensions shall be in accordance with ANSI B16.5.

7.2.2 Inside Diameter

The minimum inside diameter of fittings shall be no less than the pipe except for male adapters.

8 Pipe Ends, Connections, End Protection, and Workmanship

8.1 PIPE ENDS

Pipe and fittings shall be furnished threaded, plain end, tapered, special and, or with alternate tapered ends as specified on the purchase order.

8.1.1 Threaded Ends

Threaded ends shall consist of male and female threads per ASTM D1694 or to the standard thread design in 8.1.1.1 and 8.1.1.2. Threaded joints shall meet the performance requirements of 5.6 and 5.7.

8.1.1.1 Standard Thread Design

- a. Pipe threads shall conform to API Std 5B.

Threads with the thread dimensions in API Std 5B, Table 14, External Upset Long Round Thread Dimensions for Fiberglass Pipe and Table 7, Casing Long-Thread Dimensions.

For the purposes of this specification, lengths L_2 and L_4 in API Std 5B, Table 14 and Table 7, 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 Std 5B, Table 2, Tolerances in Linepipe Thread Dimensions, and Table 5, Tolerances on Casing and Tubing Round Thread Dimensions.

- c. Each product with standard thread design shall be threaded with the thread size shown in Table 4.

- d. Round threads shall have a fully rounded thread root and crest as conceptually illustrated in API Std 5B, Figure 4, Casing Round Thread Form. For eight 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 ten round threads, thread root radius shall be 0.014 in. ± 0.0015 in. Thread crest radius shall be 0.017 in. ± 0.0015 in.

8.1.1.2 Gaging Practice

- 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 Std 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 5B are acceptable under this specification except as noted in 8.1.1.1 of this specification. Thread gaging procedures shall be in accordance with API RP 5B1.

Note: If needed, the non-threaded portion of the API working gages can be modified for effective gaging practice of long form threads. The manufacturer shall establish the design requirements, and procedures and gaging practices for such gages.

- b. *Gaging Practice for Alternate Pipe Connections*

For alternative thread design, the manufacturer shall establish the design requirements and procedure for gaging practices.

- c. Use of Master Gages

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.

8.1.2 Plain Ends

Plain end pipe shall be furnished in lengths specified on the purchase order with square cut ends. Bell and spigot dimensions and tolerances are shown in Table 6.

8.1.3 Tapered Ends

Tapered ends shall consist of tapered spigots with either integral bells or sleeve couplings. Male and female ends shall conform to dimensions shown in Table 5. For joints not covered by Table 5, the manufacturer shall establish the design requirements for size, pressure rating, and minimum bond length for each pressure class. Tapered joints, when bonded in accordance with manufacturer's recommendation, shall meet the performance requirements of 5.6 and 5.7.

8.1.4 Special Ends

When so specified on the purchase order, pipe shall be furnished with ends suitable for use with special couplings. Mechanical joints with elastomeric seals are considered special ends. These special end connections, when joined in accordance with manufacturer's recommendations, shall meet the performance requirements of 5.6 and 5.7.

8.1.5 Alternate Tapered Ends

Alternate tapered ends which do not meet the taper angle and spigot end diameter requirements shown in Table 5 for nominal sizes 8 in. through 16 in. shall be allowed and shall be identified by the letters "ATE" following the API monogram. Alternate tapered end joints, when bonded in accordance with manufacturer's recommendation, shall meet the performance requirement of 5.6 and 5.7.

The angle of alternate taper angle shall be identified in the pipe marking immediately following "ATE" when an alternate taper angle is used.

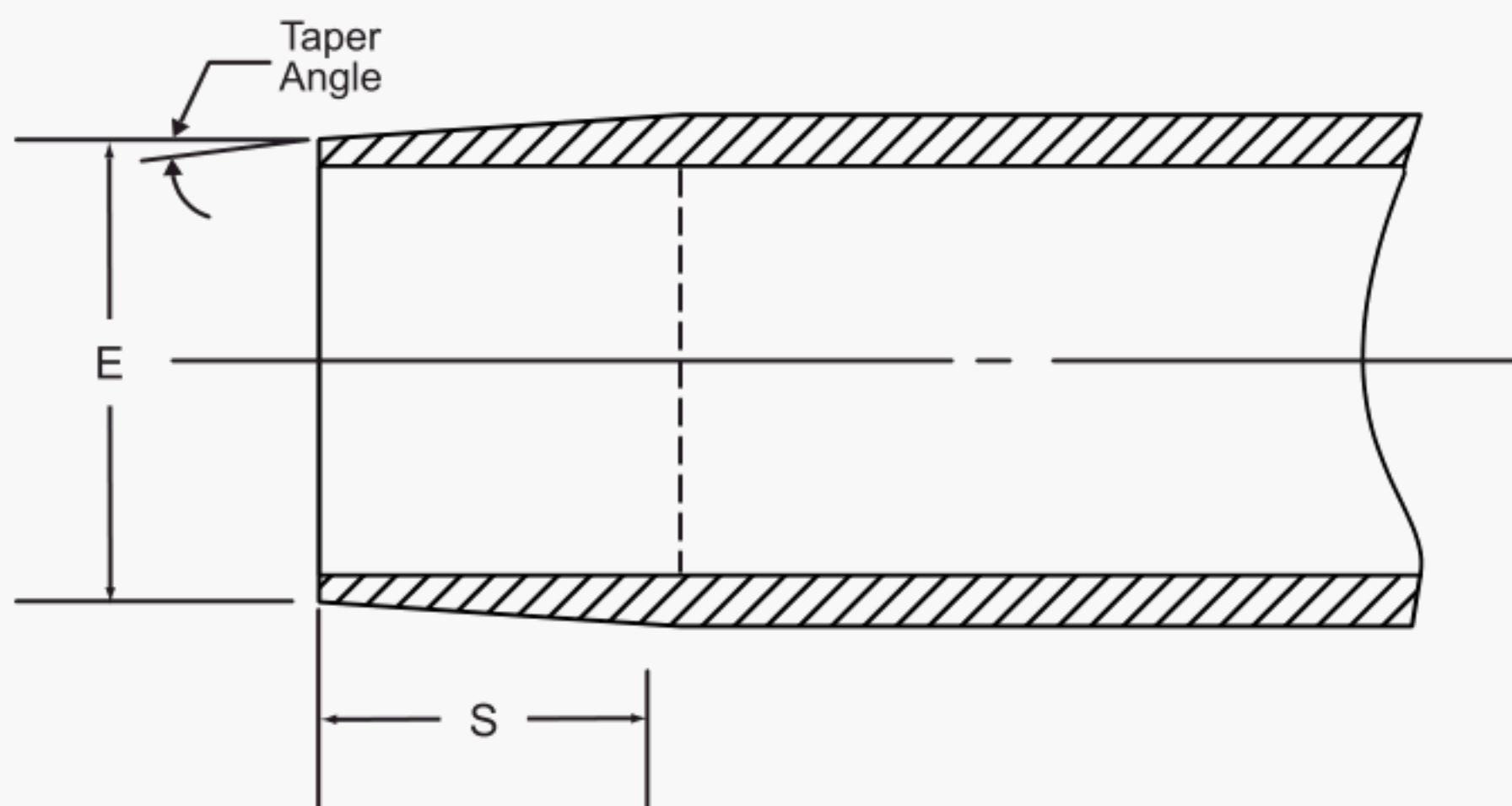
Table 4—Thread Sizes

Nominal Diameter	Thread Size
1	1.660 ¹
1 1/2	1.900 ¹
2	2 3/8 ¹
2 1/2	2 7/8 ¹
3	3 1/2 ¹
3 1/2	4 ¹
4	4 1/2 ¹
5	5 1/2 ²
6	6 5/8 ² or 7 ²
8	8 5/8 ² or 9 5/8 ²

¹API Standard 5B, Table 14 (External Upset Long Thread Dimensions for Fiberglass Pipe).

²API Standard 5B, Table 7 (Casing Long-Thread Dimensions).

Table 5—Spigot Dimensions for Tapered Ends Adhesive Bonded Joints



Nominal Pipe Size (in.)	Taper Angle (degrees)	Spigot End Dia. ¹ E (in.)	Minimum Bond Length ² S (in.)	Maximum Cyclic Pressure Rating (psi)
1	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	—	0.75	300
1 1/2	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	—	0.85	300
2	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	2.291	0.900	300
2 1/2	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	2.783	1.070	300
3	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	3.401	1.370	300
4	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	4.370	1.895	300
5	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	—	2.30	300
6	$1\frac{3}{4}$ ⁺⁰ / _{-1/4}	6.472	2.690	300

¹Spigot end diameter (E) is a reference dimension: the actual spigot diameter may be smaller.

²The minimum bond lengths are based on an adhesive shear stress of approximately 145 psi at the cyclic pressure rating.

8.2 PRODUCT DRAWINGS

The manufacturer shall furnish drawings of the pipe, fittings and any special couplings or sealing devices, including dimensions and tolerances, when requested by the purchaser.

8.3 WORKMANSHIP

All products furnished to this specification shall meet the visual inspection limits listed in Table 7.

8.4 REPAIR OF SURFACE IMPERFECTIONS

Removal of surface imperfections by methods such as grinding or filing shall be permissible provided the grinding or filing does not cut into any of the reinforcement, and that all ground or filed areas are coated prior to shipment with the same base resin as was used in the manufacture of the product.

8.5 END PROTECTION

The manufacturer shall provide end protection of such design, material and mechanical strength to protect the ends of the pipe, fittings and end connections from damage under

normal handling and transportation. The end protector for female ends shall cover the end to prevent damage by ultra-violet radiation and other weather elements. The end protector's length shall be long enough to cover:

- All effective threads of male connections.
- All machined or ground surfaces of male end (spigot) adhesive bonded joints.
- All sealing surfaces of elastomeric sealed joints.

8.6 PURCHASER INSPECTION

When stated on the purchase order, the provisions of Appendix H shall apply.

9 Marking

9.1 METHODS

Products 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 permanent, shall not overlap, and shall be applied in such manner as not to damage the product.

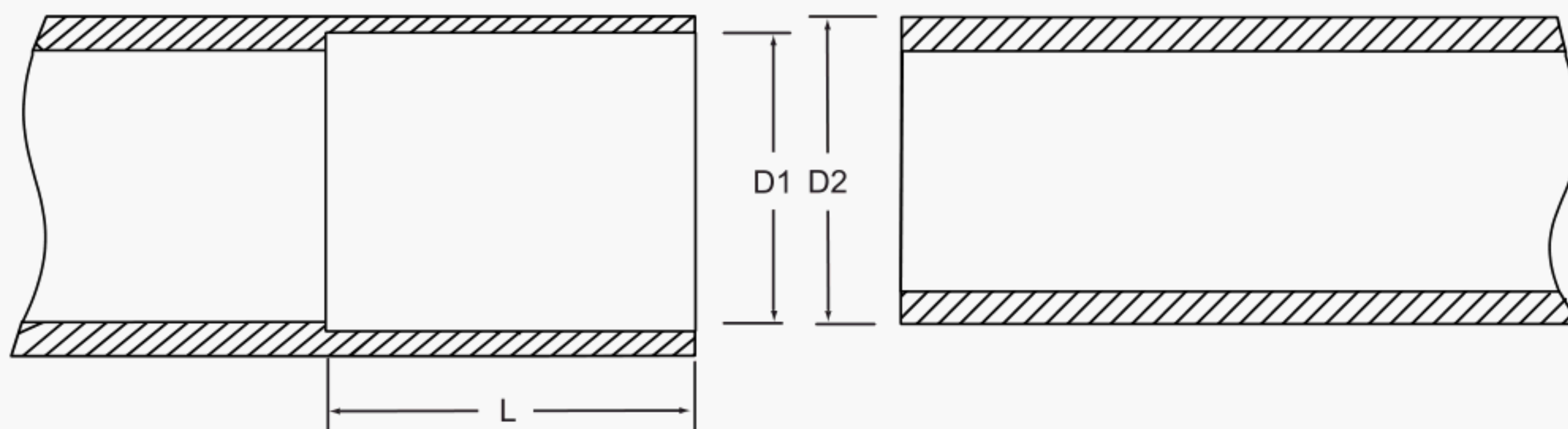
9.2 MARKING REQUIREMENTS

Products shall be marked with the following:

- Manufacturer's name or mark
- Size, nominal, inches
- Cyclic pressure rating, and static pressure rating if used.
- Temperature at which ratings apply
- Lot number
- "Spec 15LR"*

*Users of this 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 use of the monogram is contained in Appendix F. No other use of the monogram is permitted. Licensees may mark products in conformance with Section 9 or Appendix F, and nonlicensees may mark products in accordance with Section 9.

Table 6—Socket Dimensions for Adhesive Bonded Joints Using Non-Tapered Pipe Ends



Nominal Pipe Size (in.)	Socket Dimensions		Pipe Dimension	
	Length Minimum L (in.)	Diameter of Bore D1 (in.)		Outside Diameter D2 (in.)
		Min.	Max.	Outside Diameter Tolerances (in.)
2	1 3/4	2.387	2.437	2.375 ±0.012
2 1/2	1 3/4	2.887	2.937	2.875 ±0.012
3	1 3/4	3.512	3.562	3.500 ±0.012
4	1 3/4	4.515	4.562	4.500 ±0.015
6	1 3/4	6.650	6.687	6.625 ±0.025
8	1 3/4	8.650	8.687	8.625 ±0.025
10	3 3/4	10.775	10.812	10.750 ±0.025
12	3 3/4	12.775	12.812	12.750 ±0.025
14	3 3/4	14.025	14.062	14.000 ±0.025

Table 7—Visual Standards

Defect Pipe Body and Collar	Description	Maximum Size
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 one square inch maximum size maximum depth of 10% of the nominal wall thickness
Dry Spot	area where reinforcement was not thoroughly wet with resin	maximum 3 streaks per pipe- $\frac{1}{2}$ inch wide, 4 in. long, no dry reinforcement exposed
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 $\frac{1}{16}$ " deep, no limit on number
Resin Drip	resin protrusion	maximum $\frac{1}{8}$ " high, no limit on number
Scratch	shallow mark caused by improper handling	no limit on number if reinforcement is not exposed
Threads		
Air Bubbles	light patch at the root of the thread caused by entrapped air	maximum size $\frac{1}{8}$ " in any direction and one bubble allowed per connection
Chips	areas where over 10% of thread height is removed	maximum $\frac{1}{2}$ " long in one thread per connection

APPENDIX A—METHOD OF TEST FOR GLASS-RESIN RATIO OF FIBERGLASS PIPE

A.1 Scope

This appendix covers method of test for the determination of the glass-resin ratio of fiberglass products.

A.2 Summary of Method

The Glass-Resin Ratio Test consists of cutting a 1 inch \times 1 inch sample from the pipe wall, containing it in a crucible, igniting the material, and allowing it to burn until only ash and carbon remain. The carbonaceous residue is reduced to an ash by heating in a muffle furnace at 1050°F (565°C) cooled in a desiccator and weighed.

A.3 Equipment

- Crucible, made of platinum or porcelain, approximately 30 ml capacity.
- Electric Muffle Furnace, capable of maintaining a temperature of 1050° \pm 50°F (565° \pm 28°C).

A.4 Procedure

- Heat a crucible at 932° to 1112°F (500° to 600°C) for 10 minutes or more. Cool to room temperature in a desiccator and weigh to the nearest 1.0 mg.
- Place approximately 5 g. of sample in the crucible and weigh to the nearest 1.0 mg. The maximum size of the sample pieces shall be 1 in. \times 1 in. \times thickness (25.4 \times 25.4 mm). Heat the crucible and sample in a Bunsen flame until the contents ignite. Maintain such a temperature that the sample burns at a uniform and moderate rate until only ash and carbon remain when the burning ceases.

Note 1: It is often convenient to use samples obtained from specimens that have been tested for mechanical properties such as flexural or tensile strength. The samples must be dry and the fractured areas removed, leaving square, unfrayed faces, before these samples are weighed and ignited

Note 2: It is not absolutely necessary to ignite the sample in a Bunsen flame. Instead the crucible and contents can be placed in a muffle furnace at a temperature lower than 1050°F (565°C) and ignited. Care must be taken that there will be no mechanical loss of the non-combustible residue.

Note 3: If the "volatile" content of the sample is desired, determine the height loss of the crucible and contents after placing in an oven at 212°F (100°C) before ignition. The time crucible and contents must remain in the oven is dependent on the type of "volatiles" present and the specimen geometry.

- Heat the crucible and residue in the muffle furnace at 1050° \pm 50°F (568° \pm 28°C) until all carbonaceous material

has disappeared. Cool the crucible to room temperature in a desiccator and weigh to the nearest 1.0 mg.

Note 4: The time for the carbonaceous residue to disappear is dependent largely on the sample geometry. It can be up to six hours but is usually much less.

- Reheat the crucible at 1050°F (565°C) for 10 to 20 minutes, cool in a desiccator and reweigh. Repeat the heating and weighing until consecutive weighings differ by no more than 1.0 mg.
- Determine the ignition loss on at least two more portions of the same reinforced resin sample.

A.5 Calculations

- Calculate the ignition loss of the sample as follows:

$$\text{Ignition loss, \% } w = \frac{W_1 - W_2 \times 100}{W_1} \quad \text{Equation A.1}$$

Where:

W_1 = weight of the sample, grams.

W_2 = weight of the residue, grams.

- Calculate the estimated standard deviation as follows:

$$s = \frac{\sqrt{x^2 - n(\bar{x})^2}}{\sqrt{n-1}} \quad \text{Equation A.2}$$

Where:

s = estimated standard deviation.

x = value of single observation.

n = number of observations.

\bar{x} = arithmetic mean of the set of observations

A.6 Report

The report shall include the following:

- The ignition loss, %w and standard deviation. If only glass reinforcement and organic resin were present, the ignition loss can be considered to be the resin content.
- Observations in regard to any irregularities noted in the physical properties of the residue, such as melting.
- Product identification from number on product.
- Any irregularities noted during the test.
- Date of test.

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

B.1 Scope

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

B.2 Definition

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

B.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 six month intervals, whichever is shorter.

B.4 Test Specimens

B.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.

B.4.2 location: For any given tubular product, a sample should 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 and outer edges of the over-wrap.

B.5 Procedure

B.5.1 Maximum heating rate is 40°C/minute.

B.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.

B.5.3 Obtain the T_g .

B.6 Report

The report shall include the following items.

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

B.6.2 Product dimensions, including nominal size, minimum reinforced wall thickness, and average outside diameter. Unreinforced thicknesses (i.e., liner) shall also be reported.

B.6.3 Number of specimens tested and where the specimens were taken from the product.

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

B.6.5 Record the inflection value for the first scan as the glass transition temperature, T_g .

B.6.6 Date of test.

B.6.7 Test laboratory and supervisor of tests.

APPENDIX C—METHOD OF TEST FOR IMPACT RESISTANCE OF FIBERGLASS PIPE

C.1 Scope

This appendix covers the method of test for the determination of impact resistance of fiberglass pipe.

C.2 Apparatus

- a. A steel ball 2.0 inches in diameter weighing about 1.2 pounds and flat pipe support.
- b. Pipe specimen pressurization equipment, soluble fluorescent dye, and ultraviolet lamp.

C.3 Test Specimens and Conditions

One sample each in 1, 1 1/2, 2, 3, 4, 5 and 6-in. diameter shall be tested at 73.4°F. The pipe shall be fitted with suitable end closures to permit the sample to be pressurized. The specimen length between the end closures shall be not less than five times the outside diameter of the pipe, but in no case less than 12 in.

C.4 Procedure

- a. A steel ball 2.0 in. in diameter and weighing about 1.2 lbs shall be dropped squarely onto the surface of the pipe with a free fall (which may be guided) for a distance of 12 in. The ball shall be caught or deflected after the hit so that the

rebound does not hit the pipe. The pipe shall be full of water containing a soluble fluorescent dye, but not pressurized.

- b. The pipe shall be supported on 1/2-in. or thicker steel solid flat support. Four drops shall be made on randomly selected areas which are a minimum of one pipe diameter and 90 degrees clockwise from each other.

- c. The pipe shall then be pressurized to 3.5 times the cyclic rated pressure and shall remain at this pressure for five minutes.

- d. The pipe shall be examined with an ultraviolet lamp and the unaided eye. Failure in the test specimens shall be leaking or porosity, or any visible shattering, crack, or split from the impact.

C.5 Report

The report shall include the following items:

- a. Complete identification of the specimens, including material, manufacturer's name and lot number.
- b. Pipe dimensions including nominal size, minimum reinforced wall thickness and average outside diameter of reinforced wall. Unreinforced thicknesses (i.e., liner) shall also be reported.
- c. Number of specimens tested and where the specimens were taken from the pipe.
- d. Mode of failure or other visual indications.
- e. Date of test

**APPENDIX D—SAMPLING PLAN BASIS: 0.75% AOQL
(AVERAGE OUTGOING QUALITY LIMIT)**

Lot Size (No. of units)	Sample Size	Allowable No. of Failures to Accept Lot	No. of Failures to Reject Lot
0 – 30	ALL	0	1
31 – 50	25	0	1
51 – 100	33	0	1
101 – 200	39	0	1
201 – 400	44	0	1

APPENDIX E—PRODUCT CHARACTERISTICS

Changes in the following characteristics of the system shall require testing in accordance with 5.2.2.2.

E.1 Reinforcement

Significant changes shall be filament diameter, yield, or weight; reinforcement finish (sizing); reinforcement manufacturing process (e.g., single end or multiple end); and reinforcement composition.

E.2 Matrix Material (Resin System)

Significant changes shall be resin type, curing agent(s) system, curing temperature, and curing schedule for heat-cured products outside manufacturer's specified tolerances.

E.3 Liner

Significant changes shall be the composition, curing, and thickness outside manufacturer's specified tolerances.

E.4 Geometry

Significant changes shall be the winding angle(s) in excess of ± 5 degrees; number of resin reinforcement layers and/or reinforcement layer thickness in excess of 30% and/or stacking sequence; percent reinforcement in each direction in excess of $\pm 3\%$; and glass to resin ratio in excess of $\pm 3\%$.

E.5 Report

Use of the reporting format in Table E.1 is recommended.

Table E.1—Reporting Format for API Spec 15LR Appendix E
Product Characteristics

E-1 Reinforcement:

Reinforcement manufacturer: _____

Reinforcement manufacturer's product code number: _____

Filament Diameter: _____

Nominal Yield: _____

Reinforcement manufacturer's sizing code number: _____

Form (e.g. single end or multiple end): _____

Reinforcement composition: _____

E-2 Matrix material:

Resin type: _____

Resin manufacturer: _____

Resin manufacturer's product code number: _____

Curing agent(s) system: _____

Curing temperature: _____

Curing schedule: _____

E-3 Liner (if any):

Resin type: _____

Resin manufacturer: _____

Resin manufacturer's product code number: _____

Curing agent(s) system: _____

Curing temperature: _____

Curing schedule: _____

Nominal thickness: _____

Minimum thickness: _____

Maximum thickness: _____

E-4 Geometry:

Wind angle(s): _____

Number of reinforcement layers: _____

Nominal reinforcement layer thickness: _____


Stacking sequence: _____

Percent reinforcement in each direction: _____

Glass to resin ratio: _____

APPENDIX F—MARKING REQUIREMENTS FOR MONOGRAM LICENSEES

F.1 General

The marking requirements in this appendix apply to licensed manufacturers using the API monogram  on products covered by this specification.

The API monogram shall be applied only by licensed manufacturers. Contact API for information on monogram license requirements.

Products manufactured in accordance with this specification may be marked by the licensee as specified in Appendix F or Section 9. Products to which the monogram is applied shall be marked as specified in Appendix F.

F.2 Marking Requirements for API Licensees

F.2.1 Products manufactured in conformance with this specification shall be marked by the manufacturer as speci-

fied in 9.2 or F.2.2. (Additional markings as desired by the manufacturer or as requested by the purchaser are not prohibited.) Markings shall be permanent, shall not overlap, and shall be applied in such manner as not to damage the product.

F.2.2 Products shall be marked with the following:

- a. Manufacturer's name or mark
- b. Size, nominal, inches
- c. Cyclic pressure rating, or static if applicable
- d. Temperature at which ratings apply
- e. Lot number
- f. API monogram
- g. API license number
- h. Date of manufacture

APPENDIX G—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 (psi)	= 0.06894757 Bar Note: 1 Bar = 100 kilopascals (kPa)
STRENGTH OR STRESS	1 pound per square inch (psi)	= 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): $^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$	
MASS	1 pound (lb)	= 0.4535924 kilograms (kg)

APPENDIX H—PURCHASER INSPECTION

H.1 Inspection Notice

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

H.2 Plant Access

The inspector representing the purchaser shall have unrestricted access at all times while work on contract of the purchaser is being performed, to all parts of the manufacturer's plant which will concern the manufacture of the product ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the product 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.

H.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.

H.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 manufacture and the purchaser.



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