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Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping —

Part 2: Qualification and manufacture

Industries du pétrole et du gaz naturel — Canalisations en plastique renforcé de verre (PRV) —
Partie 2: Qualification et fabrication

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

This second edition cancels and replaces the first edition (ISO 14692-2:2002), which has been technically revised. It also incorporates the Technical Corrigendum ISO 14692-2:2002/Cor 1:2005.

A list of all the parts of ISO 14692 can be found on the ISO website.

Introduction

The objective of this document is to enable the purchase of GRP components with known and consistent properties from any source. Main users of this document will be the principal and the manufacturer, certifying authorities and government agencies.

The qualification programme and the quality programme are the most significant clauses in this document.

Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping —

Part 2: Qualification and manufacture

1 Scope

This document gives requirements for the qualification and manufacture of GRP piping and fittings in order to enable the purchase of GRP components with known and consistent properties from any source.

It is applicable to qualification procedures, preferred dimensions, quality programmes, component marking and documentation.

This document is intended to be read in conjunction with ISO 14692-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 834-1, *Fire-resistance tests — Elements of building construction — Part 1: General requirements*

ISO 1172, *Textile-glass-reinforced plastics — Prepregs, moulding compounds and laminates — Determination of the textile-glass and mineral-filler content — Calcination methods*

ISO 4901, *Reinforced plastics based on unsaturated-polyester resins — Determination of the residual styrene monomer content, as well as the content of other volatile aromatic hydrocarbons, by gas chromatography*

ISO 11357-2, *Plastics — Differential scanning calorimetry (DSC) — Part 2: Determination of glass transition temperature and glass transition step height*

ISO 11359-2, *Plastics — Thermomechanical analysis (TMA) — Part 2: Determination of coefficient of linear thermal expansion and glass transition temperature*

ISO 14130, *Fibre-reinforced plastic composites — Determination of apparent interlaminar shear strength by short-beam method*

ISO 14692-1:2017, *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 1: Vocabulary, symbols, applications and materials*

ISO 14692-3:2017, *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 3: System design*

ISO 14692-4:2017, *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 4: Fabrication, installation, inspection and maintenance*

API 15HR, Specification for high pressure fiberglass line pipe, Fourth Edition

ASME RTP-1-2007, *Reinforced thermoset plastic corrosion-resistant equipment*

ASTM D638, *Standard test method for tensile properties of plastics*

ASTM D696, *Standard test method for coefficient of linear thermal expansion of plastics between –30 °C and 30 °C with a vitreous silica dilatometer*

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

ASTM D2105, *Standard test method for longitudinal tensile properties of "fiberglass" (glass-fiber-reinforced thermosetting-resin) pipe and tube*

ASTM D2412, *Standard test method for determination of external loading characteristics of plastic pipe by parallel-plate loading*

ASTM D2583, *Standard test method for indentation hardness of rigid plastics by means of a barcol impressor*

ASTM D2992, *Standard practice for obtaining hydrostatic or pressure design basis for "fiberglass" (glass-fiber-reinforced thermosetting-resin) pipe and fittings*

ASTM D3567, *Standard practice for determining dimensions of "fiberglass" (glass-fiber-reinforced thermosetting resin) pipe and fittings*

ASTM E1529, *Standard test methods for determining effects of large hydrocarbon pool fires on structural members and assemblies*

IMO MSC.61(67), *Adoption of the International Code for application of fire test procedures*

IMO Resolution A.653(16), *Fire test procedures for surface flammability of bulkhead, ceiling and deck finsh materials as amended by Resolution IMO MSC.61(67): Annex 1 Part 5*

3 Terms, definitions, symbols and abbreviated terms

For the purposes of this document, the terms, definitions, symbols and abbreviated terms given in ISO 14692-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Manufacturer's declarations

4.1 Procedure

Prior to the start of the qualification programme, the manufacturer shall declare:

a) G_{xx};

b) MPR_{xx};

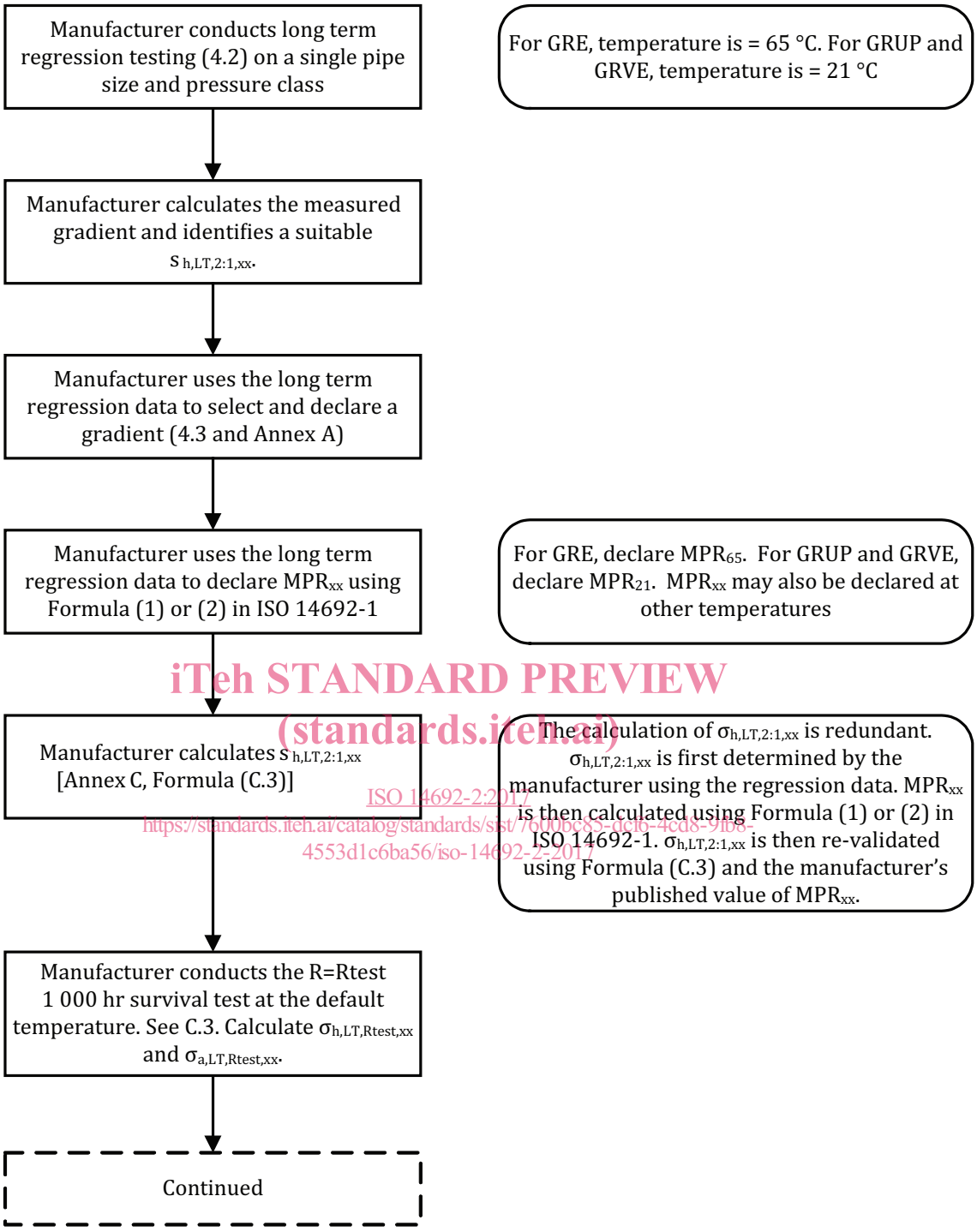
c) the long term envelope data points;

d) the threshold envelope data points;

e) dimensional data;

f) baseline values for degree of cure, barcol hardness (GRUP and GRVE only) and glass content, where applicable.

The data shall be based on a standard design life of 20 years. Figure 1 provides a flowchart of the procedure for declaring the manufacturer's data.



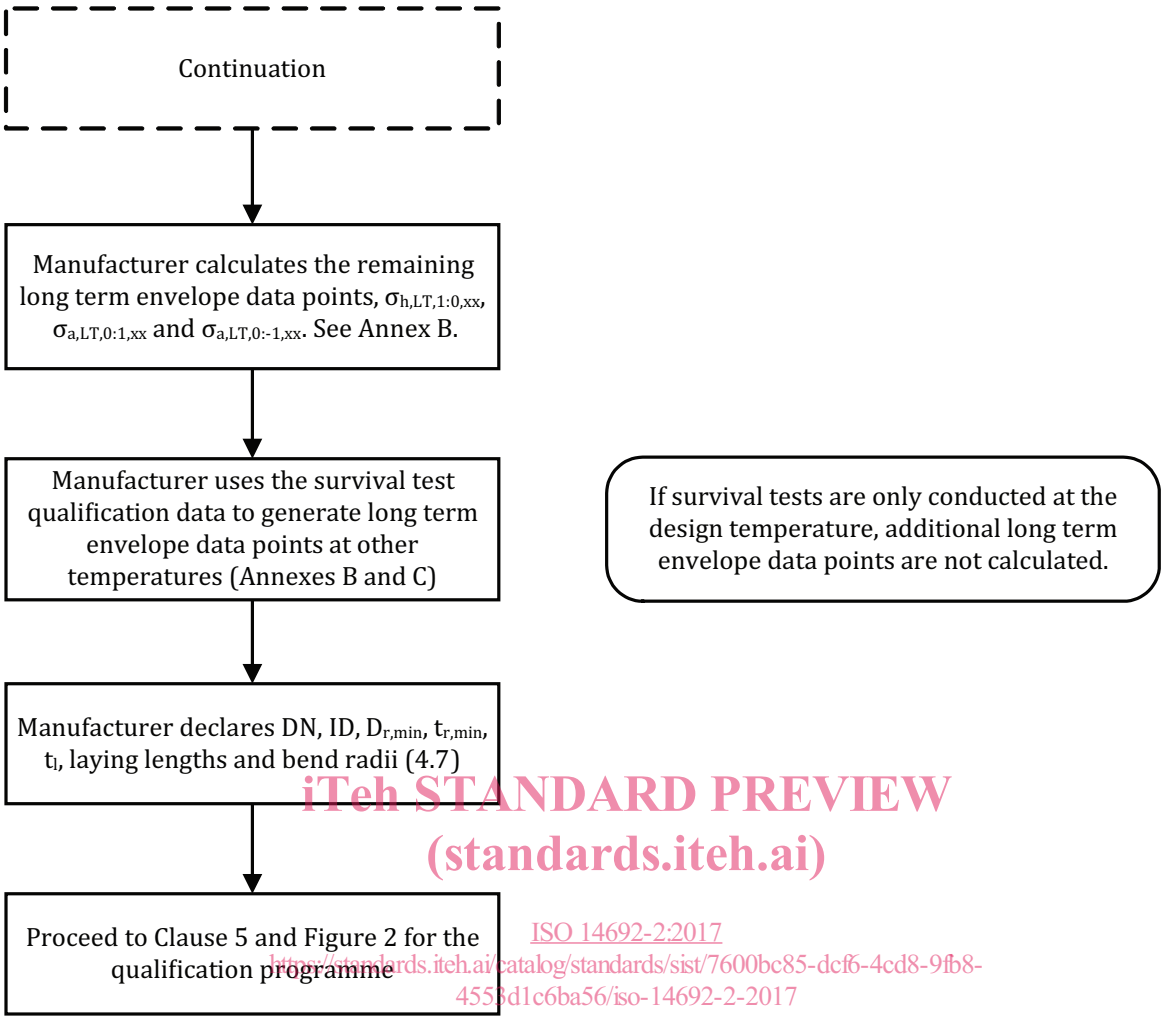


Figure 1 — Procedure for declaring manufacturer's data

4.2 Long term regression testing

The manufacturer shall provide at least one full regression curve as per ASTM D2992 as modified in this subclause and in 5.1. The regression curve shall be at 65 °C or higher for GRE and 21 °C or higher for GRUP or GRVE.

The manufacturer's gradient from the full regression curve shall be compared with the values in Table A.1 and a gradient can be selected per the process in Annex A.

NOTE 1 The one full regression curve does not have to be at or above the design temperature of the project. For example, the enquiry sheet specifies a design temperature of 93 °C and the manufacturer has a full regression curve at 85 °C for GRE-Aliphatic Amine. Since the resin matrix is GRE and the temperature of the full regression curve is above 65 °C, the data are acceptable. On the other hand, validation of the long term envelope via survial tests would have to be performed at the design temperature of the project.

The manufacturer shall conduct the long term regression on either a plain pipe or a pipe+joint, for one pipe diameter only, the diameter to be determined by the manufacturer.

NOTE 2 For economical and practical reasons, long term regression testing is typically conducted on small diameters. The recommended minimum pipe size is DN50. Data seems to be more consistent as the size increases (i.e. DN100 test results seem to be more consistent than DN50 test results).

The $D_{r,min}/t_{r,min}$ ratio of the pipe size shall be within the range of published $D_{r,min}/t_{r,min}$ ratios that are to be qualified. Ideally, the $D_{r,min}/t_{r,min}$ ratio of the pipe size should be close to the average $D_{r,min}/t_{r,min}$ ratio of all of the pipe sizes to be qualified. It is not desirable to have the $D_{r,min}/t_{r,min}$ ratio of the pipe size at either extreme.

The test fluid shall be potable water. For testing completed prior to the publication of this document, the test fluid may be salt water. In this case, the salt content shall be specified and shall not be greater than 35 g/L. The intention of this requirement is to allow validation of existing test data, but to require potable water for future testing. Potable water is a more aggressive test medium than salt water. Test data using mineral oil should be rejected since mineral oil is not a degrading agent to the bond between the glass fibres and the resin matrix.

All tests shall be conducted with unrestrained (i.e. "free") ends.

4.3 Gradient, G_{xx}

The manufacturer shall declare gradient, G_{xx}, in accordance with Annex A.

4.4 MPR_{xx}

MPR_{xx} shall be defined in accordance with ISO 14692-1:2017, 4.1.

For design temperatures in excess of 65 °C for GRE and 21 °C for GRUP and GRVE, the manufacturer shall also publish MPR_{xx} at the design temperature or higher.

The following shall be taken into account:

a) Default temperatures are 65 °C (MPR_{65}) for GRE and 21 °C (MPR_{21}) for GRVE and GRUP. For clarity, MPR shall always be published with a temperature subscript (e.g. MPR_{65} or MPR_{21}, not MPR).

b) The default temperature for GRE is established at 65 °C since this temperature is at or above the design temperature for many typical GRE applications and since many manufacturers have conducted qualification testing for pressure at this temperature.

c) The default temperature for GRUP is established at 21 °C since there are many applications for GRUP near ambient temperature and the amount of qualification testing for pressure by manufacturers at 65 °C is less than that at 21 °C to 50 °C.

d) GRVE can be suitable for applications at temperatures above 65 °C. However, the amount of qualification testing for pressure above 65 °C by manufacturers is very small. Like GRUP, there is more qualification data between 21 °C to 50 °C, thus the default temperature for GRVE is established at 21 °C.

e) The manufacturer uses the survival tests to validate MPR_{xx} (see 5.3.1).

4.5 Partial factors

4.5.1 Partial factor for design lifetime, A_0

The partial factor for design lifetime, A_0, is specified in ISO 14692-3:2017, 6.1.1.

4.5.2 Partial factor for chemical degradation, A_2

The partial factor for chemical degradation, A_2, shall be 1,0.

NOTE 1 It is the resin rich liner, not the structural cage, that is designed to prevent chemical degradation. A partial factor applied to the reinforced wall thickness would provide little to no value in preventing chemical degradation.

NOTE 2 Water permeates thermoset resins quite quickly. The silane coupling agent is the key component providing resistance to breakdown from water attack. Without the silane coupling agent, water permeation would occur followed by a breakdown of the bond between the glass and resin followed by etching of the fibers and finally fiber failure.

NOTE 3 While the silane coupling agent provides resistance to breakdown from water attack, other chemicals can attack the bond between the resin and the glass reinforcement. Some of these chemicals include strong acids and bases such as sodium hydroxide. It is these chemicals that require a resin-rich, reinforced liner of sufficient thickness to protect the structural layers from permeation of these chemicals and attack of the bond between the glass and the resin. Most of these chemicals do not permeate quickly, so practical liners are possible. Other standards, such as ASTM D3681 or EN 13121-2, can be suitable as a qualification programme to predict the thickness of the liner based on exposure to various chemicals in a stressed condition.

4.5.3 Partial factor for cyclic loading, A_3

The partial factor for cyclic loading, A_3, is specified in ISO 14692-3:2017, 6.1.3.

4.6 Long term envelope data points

The manufacturer shall declare and demonstrate the long term envelope data points ($\sigma_{h,LT,2:1,xx}$, $\sigma_{a,LT,2:1,xx}$, $\sigma_{h,LT,0:1,xx}$, $\sigma_{a,LT,0:1,xx}$, $\sigma_{h,LT,Rtest,xx}$, $\sigma_{a,LT,Rtest,xx}$, $\sigma_{a,LT,0:-1,xx}$ and $\sigma_{h,LT,1:0,xx}$) and the threshold envelope data points ($\sigma_{h,thr,2:1}$, $\sigma_{a,thr,2:1}$, $\sigma_{h,thr,Rtest}$, $\sigma_{a,thr,Rtest}$, $\sigma_{a,thr,0:-1}$, and $\sigma_{h,thr,1:0}$) by testing in accordance with Annex B. The threshold envelope data points do not have a temperature subscript as the threshold is defined, by default, at 65 °C for GRE and 21 °C for GRUP and GRVE.

Long term envelope data points are defined at temperatures. To calculate a long term envelope data point, survival tests on pipe(s), joint(s) and fitting(s) are required at the design temperature (or higher) in accordance with Annex C.

4.7 Dimensions

The manufacturer shall declare the following dimensions:

a) DN;

b) ID;

c) $D_{r,min}$ and $t_{r,min}$;

d) t_l;

e) laying lengths;

f) bend radii (for elbows).

The nominal diameter should be agreed between the manufacturer and principal.

4.8 Baseline values

The manufacturer shall declare basline values for quality control puposes for the following:

a) degree of cure;

b) barcol hardness (GRUP and GRVE only);

c) glass content.

The manufacturer shall select samples from standard production to determine the baseline values.

Samples for baseline testing should be taken from standard production to ensure that results are being obtained across the entire standard deviation of the population. Samples for baseline testing should

not be limited to the 1 000 h qualification samples since these samples can be anywhere within the standard deviation of the population.

4.9 Flexibility factors and SIFs

The manufacturer shall declare flexibility factors for bends in accordance with ISO 14692-3:2017, 7.4. The manufacturer shall declare SIFs for bends and tees in accordance with ISO 14692-3:2017, 7.5.

4.10 Production processes and jointing instructions

The manufacturer shall declare general production processes and jointing instructions sufficient to verify that the scaling rules in Annex F have been met. Proprietary processes need not be disclosed.

5 Qualification programme

5.1 General

The qualification programme is a one-time process. If the manufacturer has test data from a previous project, the manufacturer may have the option to use this data on other projects. However, the principal may also have the option to require one or more of the tests in Table 1 to be conducted for their particular project. These tests shall be specified on the enquiry sheet (refer to ISO 14692-1:2017, Annex D). The principal may also have the option, via the enquiry sheet in ISO 14692-1:2017, Annex D, to specify which tests, if any, shall be conducted by a laboratory that meets ISO/IEC 17025.

The qualification programme shall be based on a standard design life of 20 years. A_0 shall be used to scale the design envelope to other design lives. A_0 shall not be greater than 1,0.

The test fluid for the qualification procedure for pressure and temperature shall be potable water. See also 4.2 for a clarification of the test fluid.

All tests involving internal pressure shall be conducted with unrestrained (i.e. "free") ends.

Table 1 provides a summary of the qualification programme. Figure 2 shows a flowchart of the procedure for product qualification. Figure 3 shows a flowchart of the procedure for determining elastic properties.

Permanent repair procedures shall be qualified according to this qualification programme.

NOTE The manufacturer's repair procedures that only involve qualified components may not need any additional qualification.

When joints are qualified, the joint shall be made in accordance with the manufacturer's declared joint instructions. This qualifies both the joint and its joint instructions.

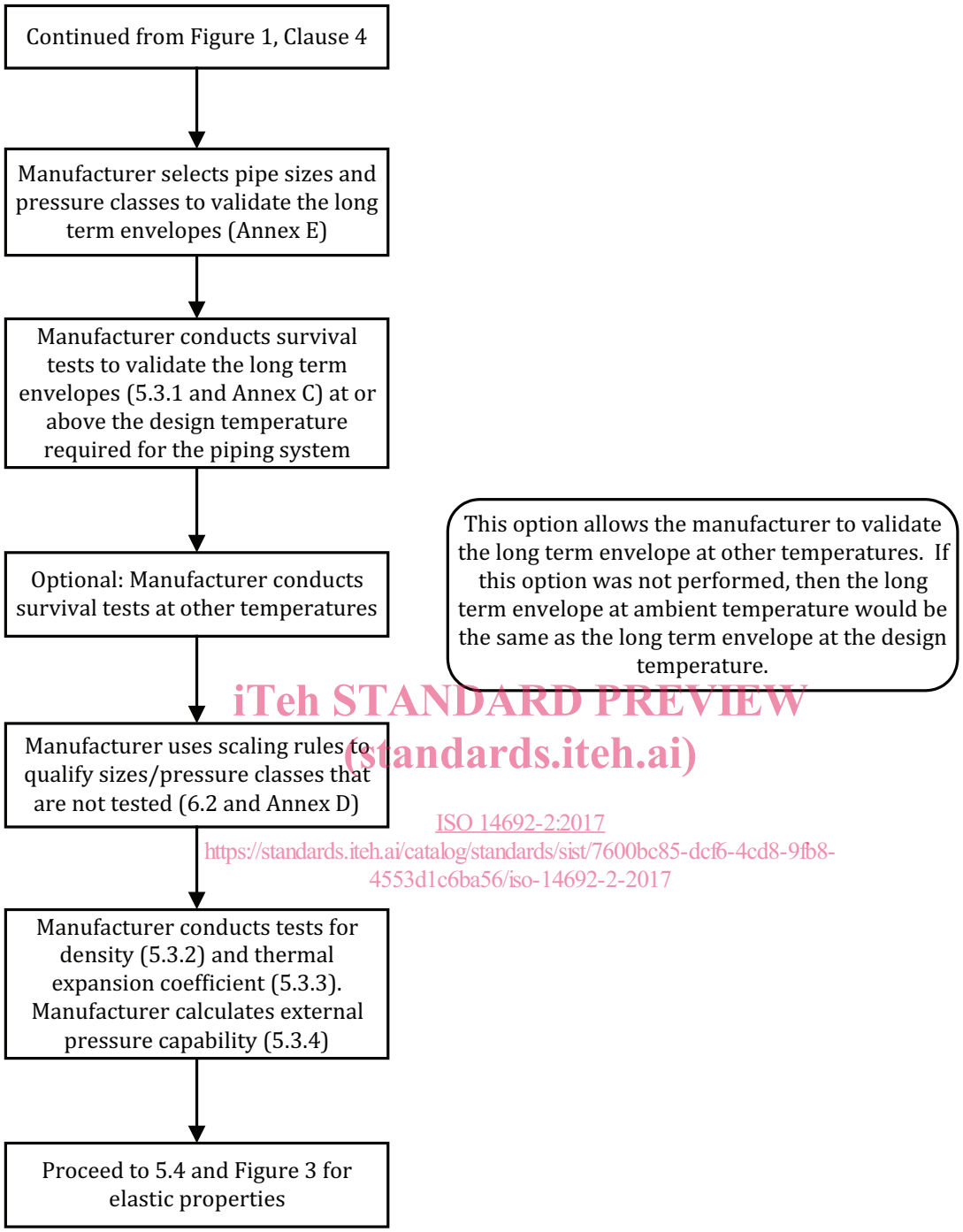


Figure 2 — Procedure for the product qualification portion of the qualification programme

Table 1 — Summary of the qualification programme

No	Ref.	Test procedure	Product(s)	Generated data	Use
Product qualification					
1	4.2	ASTM D2992	Plain pipe or pipe + joint, one size	Measured G_{xx}	To validate $rd_{1\,000}$
2	C.2.2	ASTM D1598 as modified in 5.3.1	Plain pipe or pipe + joint, one size	$R = R_{test}$ survival test	To validate the $R = R_{test}$ data point on the threshold and long term envelopes
3	5.3.1	ASTM D1598 as modified in 5.3.1	Plain pipe, sizes per 5.2 and Annex E	Survival test	To validate the threshold and long term envelopes
4	5.3.1	ASTM D1598 as modified in 5.3.1	Pipe+joint and fittings, sizes per 5.2 and Annex E	Survival test	To validate the threshold and long term envelopes
5	5.3.1 and Annex F	ASTM D1598 as modified in 5.3.1	Flanges, sizes per 5.2 and Annex E	Survival test	To validate the threshold and long term envelopes
6		10 cycle pressure test			
7		Vacuum test			
8		Combined loading test			
9	5.3.2	Manufacturer's standard	Plain pipe, one pipe size	ρ	Weight
10	5.3.3	Manufacturer's standard or ASTM D696 or ISO 11359-2	Plain pipe, one pipe size	α_a	Axial pipe deflection
11	5.3.4	ISO 14692-3:2017, 7.9 (by calculation)		External collapse pressure	Hoop pipe stability
Elastic properties					
12	5.4.2	ASTM D2105	Plain pipe, one pipe size	E_a	
13	5.4.3	Per API 15HR	Plain pipe, one pipe size	E_h and ν_{ah}	
14	5.4.4	Per Annex G	Plain pipe, one pipe size	ν_{ha}	
15	5.4.5	ASTM D2412 (buried applications only)	Plain pipe, one pipe size	E_{hb}	Hoop pipe stability, stiffness

5.2 Scaling rules

The components to be tested can be any combination of diameter, pressure class and product type. Requirements for the selection of diameter, pressure class and product type can be found in Annex E.

Once the diameters and pressure classes have been selected and the components have been tested, the manufacturer shall then use scaling rules to qualify all other components. Requirements for scaling rules can be found in Annex D.