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Entwurf

Einsprüche bis 2015-10-28
Vorgesehen als Ersatz für
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Berichtigung 1:2007-02

**Erdöl- und Erdgasindustrie –
Glasfaserverstärkte Kunststoffrohrleitungen (GFK) –
Teil 2: Zulassung und Herstellung (ISO/DIS 14692-2:2015);
Englische Fassung prEN ISO 14692-2:2015**

Petroleum and natural gas industries –
Glass-reinforced plastics (GRP) piping –
Part 2: Qualification and manufacture (ISO/DIS 14692-2:2015);
English version prEN ISO 14692-2:2015

Industries du pétrole et du gaz naturel –
Canalisations en plastique renforcé de verre (PRV) –
Partie 2: Conformité aux exigences de performance et fabrication
(ISO/DIS 14692-2:2015);
Version anglaise prEN ISO 14692-2:2015

Anwendungswarnvermerk

Dieser Norm-Entwurf mit Erscheinungsdatum 2015-08-28 wird der Öffentlichkeit zur Prüfung und Stellungnahme vorgelegt.

Weil die beabsichtigte Norm von der vorliegenden Fassung abweichen kann, ist die Anwendung dieses Entwurfes besonders zu vereinbaren.

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Die Empfänger dieses Norm-Entwurfs werden gebeten, mit ihren Kommentaren jegliche relevanten Patentrechte, die sie kennen, mitzuteilen und unterstützende Dokumentationen zur Verfügung zu stellen.

Gesamtumfang 93 Seiten

DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG)

Nationales Vorwort

Dieses Dokument (prEN ISO 14692-2:2015) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ Subkomitee SC 6 „Offshore structures“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat NEN, Niederlande) erarbeitet.

Für Deutschland hat hieran der Arbeitskreis NA 109-00-01-06 AK „Verfahrenstechnische Anlagen und Ausrüstungen“ im DIN-Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Das Ausgabedatum des Europäischen Norm-Entwurfs stand zum Zeitpunkt der Veröffentlichung dieses DIN-EN-ISO-Entwurfs noch nicht fest; der prEN ISO wird jedoch vom CMC unter der angegebenen prEN-Nummer demnächst zur CEN-Umfrage verteilt. Um der deutschen Öffentlichkeit eine möglichst lange Einspruchsfrist einzuräumen, wurde dieser Norm-Entwurf bereits vorab veröffentlicht.

Änderungen

Gegenüber DIN EN ISO 14692-2:2005-07 und DIN EN ISO 14692-2 Berichtigung 1:2007-02 wurden folgende Änderungen vorgenommen:

- a) Aufnahme neuer Abschnitt 3 „Manufacturer's declarations“;
- b) Aufnahme neuer Anhang A (normative) „MPR_{xx}“;
- c) Aufnahme neuer Anhang B (normative) „Gradients and Temperature Limits“;
- d) Aufnahme neuer Anhang C (normative) „Survival tests“;
- e) Aufnahme neuer Anhang D (normative) „Long term envelope data points“;
- f) Aufnahme neuer Anhang E (normative) „Flange qualification“;
- g) Aufnahme neuer Anhang F (normative) „Representative products“;
- h) Aufnahme neuer Anhang G (informative) „Scaling rules“;
- i) Aufnahme neuer Anhang H (normative) „Major Poisson's ratio“;
- j) Aufnahme neuer Anhang I (normative) „Alternate Material Qualification“;
- k) Aufnahme neuer Anhang J (normative) „Fire endurance testing“;
- l) Aufnahme neuer Anhang K (informative) „Example of qualification summary form“;
- m) Aufnahme neuer Anhang L (normative) „Visual Inspection“.

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benummerung der folgenden Begriffe, Symbole und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

2 Begriffe, Symbole und Abkürzungen

Für die Anwendung dieses Teils der ISO 14692 gelten die Begriffe, Symbole und Abkürzungen nach ISO 14692-1.

— Leerseite —

Contents

Page

Foreword	v
Introduction.....	vi
1 Scope	1
2 Terms, definitions, symbols and abbreviated terms	1
3 Manufacturer's declarations.....	1
3.1 Long term regression testing.....	3
3.2 Gradient, G_{xx}	4
3.3 MPR_{xx}	4
3.4 Partial factors.....	4
3.5 Long term envelope data points	5
3.6 Dimensions	5
3.7 Baseline values.....	5
3.8 Flexibility factors and SIFs	6
3.9 Production processes and jointing instructions	6
4 Qualification programme	6
4.1 General	6
4.2 Scaling rules	9
4.3 Product qualification	9
4.4 Elastic properties	10
4.5 Optional qualification requirements	13
5 Requalification	13
6 Quality programme for manufacture	14
6.1 General requirements	14
6.2 Quality control tests	15
6.3 Optional quality control tests	20
7 Component marking.....	21
8 Handling, storage and transportation	21
9 Documentation	21
9.1 Enquiry and purchase order documentation.....	21
9.2 Qualification documentation	21
9.3 Production quality control documentation.....	22
9.4 Installation documentation	23
Annex A (normative) MPR_{xx}	24
Annex B (normative) Gradients and Temperature Limits	25
Annex C (normative) Survival tests	31
Annex D (normative) Long term envelope data points	36
Annex E (normative) Flange qualification	41
Annex F (normative) Representative products	44
Annex G (informative) Scaling rules	48
Annex H (normative) Major Poisson's ratio	59
Annex I (normative) Alternate Material Qualification	62
Annex J (normative) Fire endurance testing.....	70

Annex K (informative) **Example of qualification summary form** 79

Annex L (normative) **Visual Inspection**..... 81

Bibliography 85

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14692-2 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/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

ISO 14692 consists of the following parts, under the general title *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping*:

- *Part 2: Qualification and manufacture*
- *Part [n]:*
- *Part [n+1]:*
- *Part 1: Vocabulary, symbols, applications and materials*
- *Part 2: Qualification and manufacture*
- *Part 3: System design*
- *Part 4: Fabrication, installation, inspection and maintenance*

Introduction

The objective of this part of ISO 14692 is to enable the purchase of GRP components with known and consistent properties from any source. Main users of the 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 Part 2.

Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 2: Qualification and manufacture

1 Scope

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

2 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.

3 Manufacturer's declarations

Prior to the start of the qualification programme, the manufacturer shall declare 1) G_{xx} , 2) MPR_{xx} , 3) the long term envelope data points, 4) the threshold envelope data points, 5) dimensional data and 6) 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.

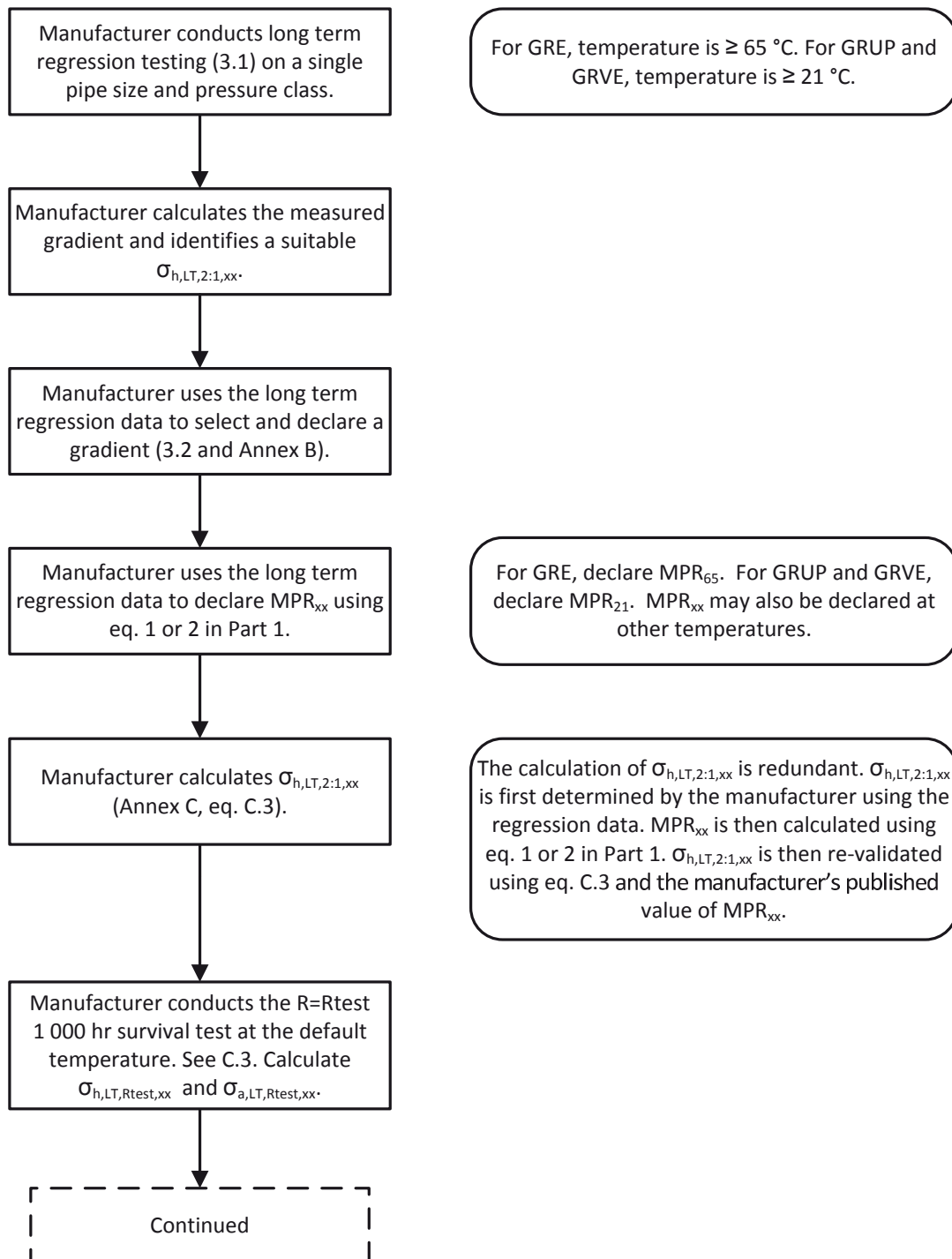


Figure 1 – Procedure for declaring manufacturer's data

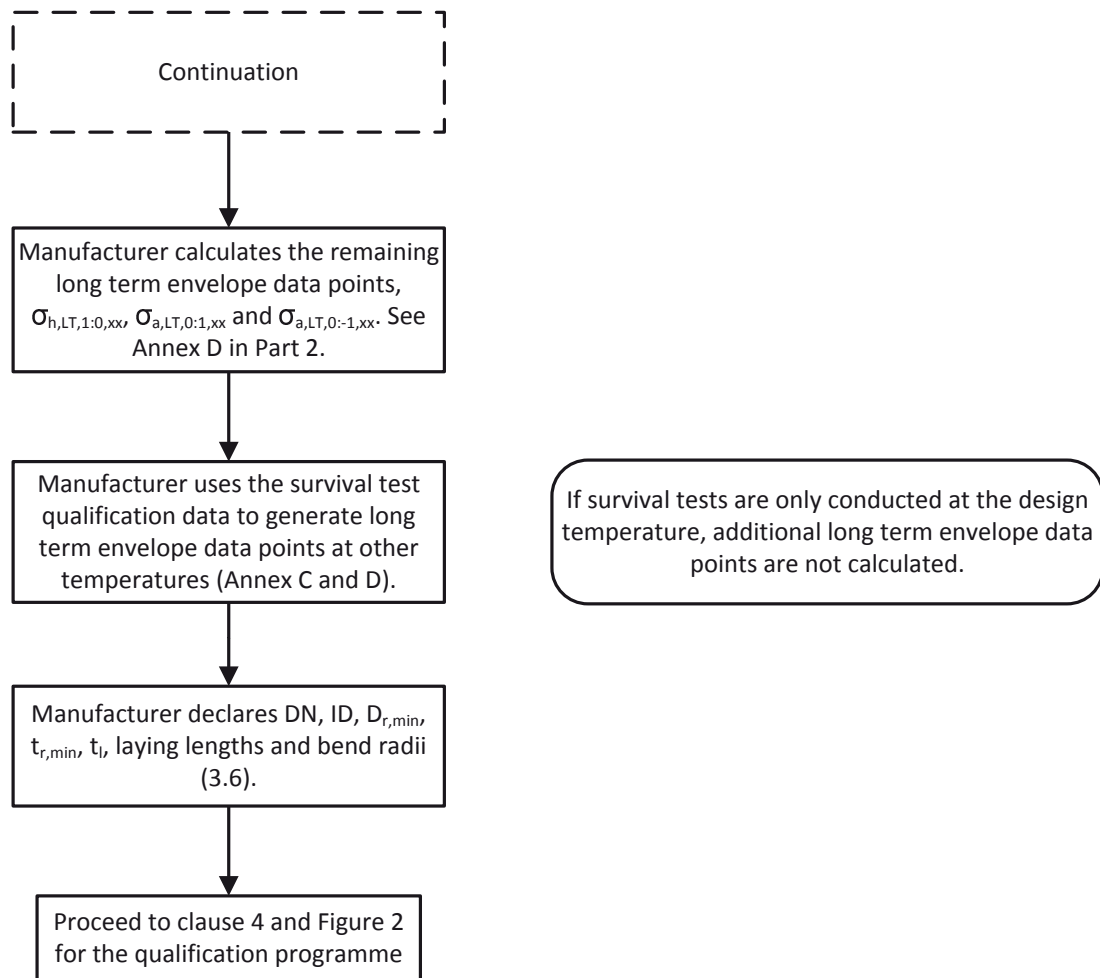


Figure 1 (continued) – Procedure for declaring manufacturer's data

3.1 Long term regression testing

The manufacturer shall provide at least one full regression curve (as per ASTM D2992 as modified in this clause and in clause 4.1). The regression curve shall be at 65 °C or higher for GRE and 21 °C or higher for GRUP or GRVE.

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 is acceptable. The manufacturer's gradient from the full regression curve can be compared to the values in Table B.1 and a gradient can be selected per the process in Annex B. On the other hand, validation of the long term envelope via survival 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, in a single pipe size, the size 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.

NOTE 3 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.

NOTE 4 For testing completed prior to the publication of this standard, the test fluid may be salt water. In this case, the salt content must be specified and it must not be greater than 35 g/L. The intention of this requirement is to allow validation of existing test data completed before the publication of this document, but to require potable water for future testing. Potable water is a more aggressive test media 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.

3.2 Gradient, G_{xx}

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

3.3 MPR_{xx}

MPR_{xx} is the maximum pressure rating at sustained conditions for a 20 year design at the temperature of xx °C. MPR_{xx} shall be the maximum catalogue value published by the manufacturer.

MPR_{xx} shall be defined at 65 °C for GRE (MPR₆₅) and 21 °C for GRUP and GRVE (MPR₂₁). 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 noted:

- a) Default temperatures are 65 °C (MPR₆₅) for GRE and 21 °C (MPR₂₁) for GRVE and GRUP. For clarity, MPR shall always be published with a temperature subscript (e.g. MPR₆₅ or MPR₂₁, 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) While GRVE may be suitable for applications at temperatures above 65 °C, 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} (clause 4.3.1).

3.4 Partial factors

3.4.1 Partial factor for design lifetime, A_0

A_0 is specified in clause 5.1.1 of ISO 14692-3.

3.4.2 Partial factor for chemical degradation, A_2

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 may 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. Fortunately, most of these chemicals do not permeate quickly, so practical liners are possible. Other standards, such as ASTM D3681 or EN 13121-2, may be suitable as a qualification programme to predict the thickness of the liner based on exposure to various chemicals in a stressed condition.

3.4.3 Partial factor for cyclic loading, A_3

A_3 is specified in clause 5.1.3 of ISO 14692-3.

3.5 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 D. 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). Refer to Annex D for calculations.

3.6 Dimensions

The manufacturer shall declare the following dimensions:

- a) DN
- b) ID
- c) $D_{r,min}$ and $t_{r,min}$
- d) t_i
- e) Laying lengths
- f) Bend radii (for elbows)

The nominal diameter should be chosen from the sizes listed in Table 1 of ISO 7370:1983 or should be agreed between the manufacturer and principal.

3.7 Baseline values

The manufacturer shall declare baseline values for quality control purposes 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.

NOTE Samples for baseline testing should not be limited to the 1000 hr qualification samples since these samples may be anywhere within the standard deviation of the population. Samples should be taken from standard production to ensure that results are being obtained across the entire standard deviation of the population.

3.8 Flexibility factors and SIFs

The manufacturer shall declare flexibility factors for bends per clause 6.4 of Part 3. The manufacturer shall declare SIFs for bends and tees per clause 6.5 of Part 3.

3.9 Production processes and jointing instructions

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

4 Qualification programme

4.1 General

The qualification programme is a one-time process. If the manufacturer has test data from a previous project, the manufacturer shall have the option to use this data on other projects. However, the principal shall 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 (ref. ISO 14692-1 Annex D). The principal shall also have the option, via the Enquiry Sheet in ISO 14692-1 Annex D, to specify which tests, if any, shall be conducted by an independent third party laboratory.

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.

NOTE 1 For testing completed prior to the publication of this standard, the test fluid may be salt water. In this case, the salt content must be specified and it must not be greater than 35 g/L. The intention of this requirement is to allow validation of existing test data completed before the publication of this document, but to require potable water for future testing. Potable water is a more aggressive test media 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 involving internal pressure shall be conducted with unrestrained (i.e. "free") ends.

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

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

NOTE 2 Manufacturer's repair procedures that only involve qualified components would 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.

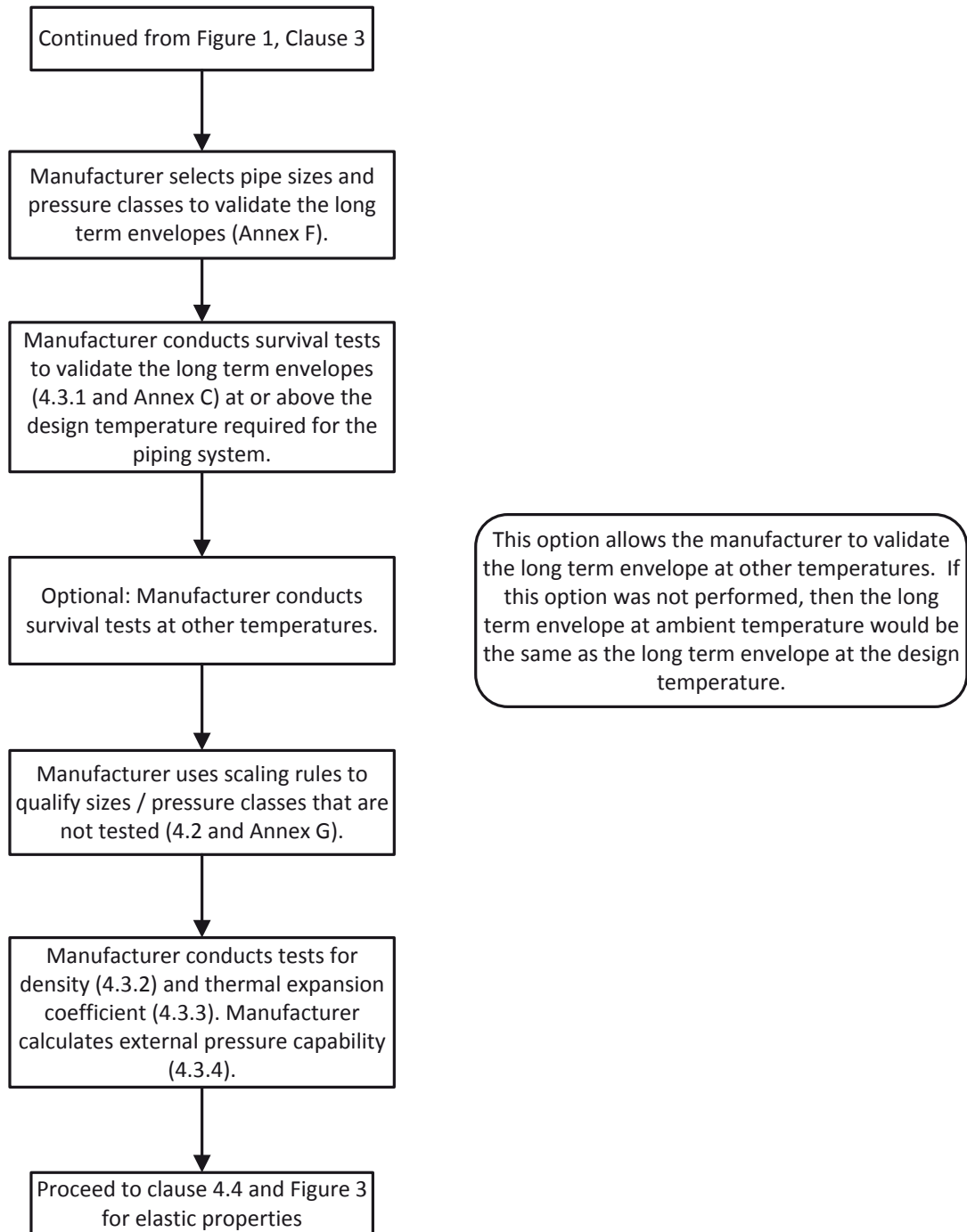


Figure 2 – Procedure for the product qualification portion of the qualification programme

Table 1 – Summary of the qualification programme

No	Ref.	Test Procedure	Product(s)	Generated Data	Use
Product qualification					
1	3.1	ASTM D2992	Plain pipe or pipe+joint, one size	Measured G_{xx}	To validate $rd_{1\ 000}$
2	D.2.2	ASTM D1598 as modified in 4.3.1	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	4.3.1	ASTM D1598 as modified in 4.3.1	Plain pipe, sizes per 4.2 and Annex F	Survival test	To validate the threshold and long term envelopes
4	4.3.1	ASTM D1598 as modified in 4.3.1	Pipe+joint and fittings, sizes per 4.2 and Annex F	Survival test	To validate the threshold and long term envelopes
5	4.3.1 and Annex E	ASTM D1598 as modified in 4.3.1	Flanges, sizes per 4.2 and Annex F	Survival test	To validate the threshold and long term envelopes
6		10 cycle pressure test			
7		Vacuum test			
8		Combined loading test			
9	4.3.2	Manufacturer's standard	Plain pipe, one pipe size	ρ	Weight
10	4.3.3	Manufacturer's standard or ASTM D696	Plain pipe, one pipe size	α_a	Axial pipe deflection
11	4.3.4	ISO 14692-3 (by calculation)		External collapse pressure	Hoop pipe stability
Elastic properties					
12	4.4.1	ASTM D2105	Plain pipe, one pipe size	E_a	
13	4.4.2	Per API 15HR	Plain pipe, one pipe size	E_h and v_{ah}	
14	4.4.3	Per Annex H	Plain pipe, one pipe size	v_{ha}	
15	4.4.4	ASTM D2412 (buried applications only)	Plain pipe, one pipe size	E_{hb}	Hoop pipe stability, stiffness

4.2 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 F.

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

4.3 Product qualification

4.3.1 Validation of long term envelopes

The manufacturer shall conduct survival test(s) on pipes, pipes+joints, fittings and flanges in accordance with ASTM D1598 with the following modifications:

- a) the requirements in 4.1 shall apply;
- b) the qualification temperature (i.e. the test temperature) for at least one set of survival tests shall be equal to or greater than the design temperature;

NOTE 1 A set is two samples of each size/component to be tested. The intention is to require the manufacture to conduct the necessary survival tests at the design temperature (or higher) of the project. A set of survival tests may also be conducted at other lower temperatures.

- c) two samples of each component / size shall be tested;
- d) the size(s) to be tested shall be determined in accordance with Annex F;
- e) the survival test time and pressure shall be calculated in accordance with Annex C;
- f) the test specimen shall show no signs of weepage or leakage during the test (i.e., the test is a survival test);
- g) the calculations in ASTM D1598 are not required;
- h) for the R=Rtest survival test, modifications to ASTM D1598 are in accordance with Annex C.

NOTE 2 Components may be tested individually or combined as a single test specimen (e.g., a manufacturer who needs to qualify a pipe, joint, bend, tee and flange in one size may elect to conduct 5 tests, one for the pipe, one for the pipe+joint, one for the bend, one for the tee and one for the flange or the manufacturer may elect to conduct a single test on an assembly with the pipe, joint, bend, tee and flange.). However, it is likely that the pipe will have to be tested separately from the fitting/joint since the $P_{T1\ 000,xx}$ of the pipe will be higher than the $P_{T1\ 000,xx}$ of the fitting/joint.

Additional requirements for flanges are in Annex E.

NOTE 3 Unlike testing for elastic properties, pre-conditioning prior to survival testing is not required, but can be performed by the manufacturer.

NOTE 4 Repeated failures of these survival tests should require reduction of the MPR_{xx} .

4.3.2 Density

ρ (density) shall be calculated according to the manufacturer's standard.

4.3.3 Thermal expansion coefficient

α_a , the thermal expansion coefficient, shall be calculated according to ASTM D696 or ISO 11359-2.

4.3.4 Qualification procedure for external pressure

The external pressure capability of pipes shall be calculated by analytical methods per ISO 14692-3 clause 6.9.

4.4 Elastic properties

Refer to Figure 3 for a flowchart of the procedure for determining elastic properties.

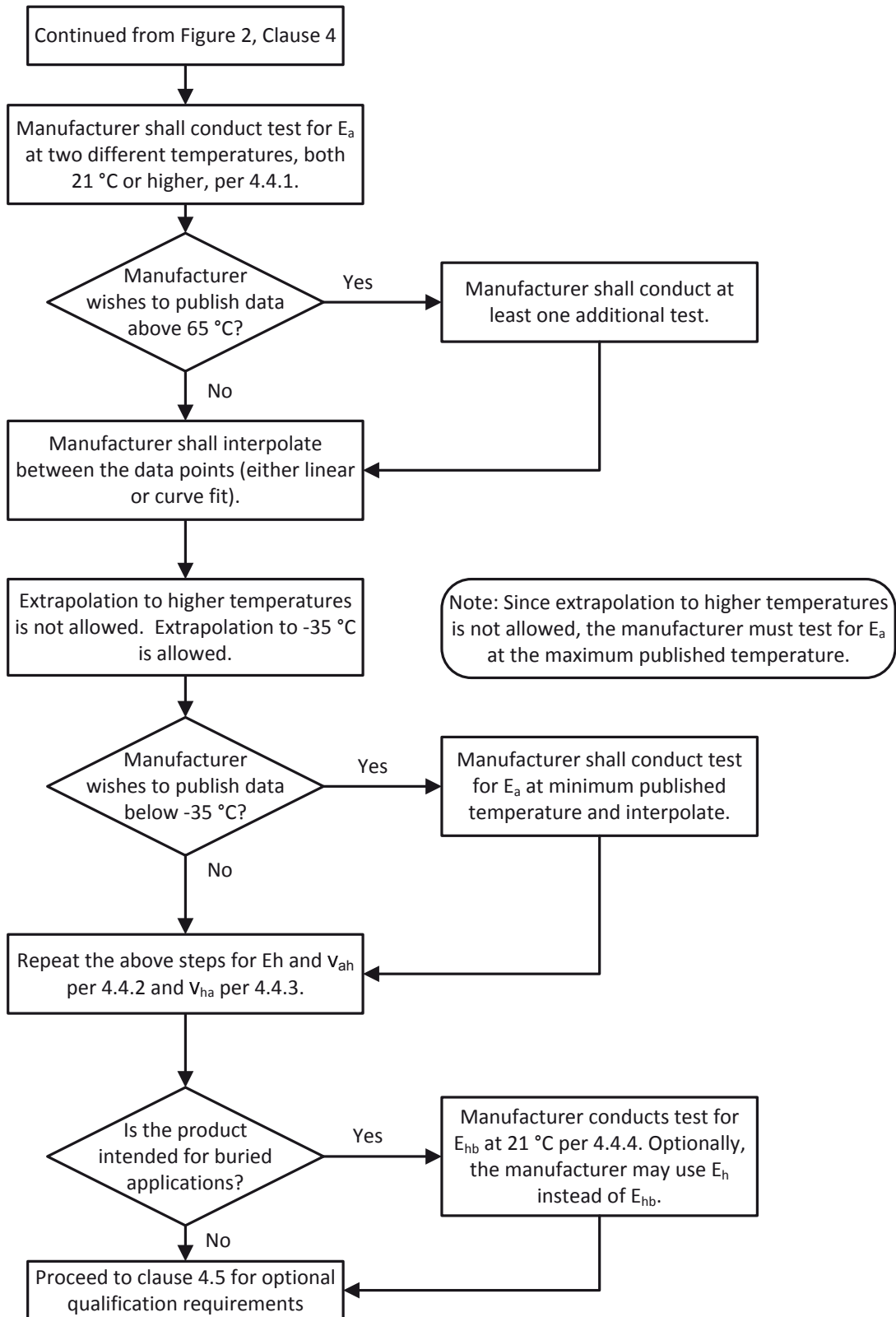


Figure 3 – Procedure to determine elastic properties

NOTE 1 Wind angle and layer thickness appear to be more important to elastic properties than the resin matrix or the curing agent.

NOTE 2 Elastic properties, such as E_a and ν_{ah} will vary by temperature. Manufacturers should provide elastic properties as a function of temperature for accurate pipeline analysis.

NOTE 3 For GRE, when the temperature is well below the T_g of the resin, the elastic properties do not appear to deviate from one GRE resin matrix to another GRE resin matrix when the layer thickness of the sample remains the same. It may be feasible to allow elastic properties for one GRE resin matrix to be used for other GRE resin matrices.

NOTE 4 Most manufacturers measure elastic properties separately in the hoop and axial direction. Unfortunately, elastic properties measured this way usually do not meet the compliance equation: $E_h / E_a = \nu_{ha} / \nu_{ah}$.

When testing for elastic properties, the test samples shall be pre-conditioned as follows: Samples are to be subject to an internal pressure test at MPR_{xx} at the test temperature "xx" for 168 h with unrestrained ends.

NOTE 5 Some form of "shakedown loading" applied to the samples prior to measuring elastic properties should be beneficial. This would eliminate residual curing shrinkage stresses in the pipe wall. The best shakedown load is to apply the rated pressure to the pipe sample as a closed end pressure vessel for one week (168 hours) at the test temperature. This would "stretch out" all residual stress, so the initial non-linear behavior would be largely eliminated.

4.4.1 Axial tensile modulus, E_a

E_a shall be determined in accordance with ASTM D2105.

NOTE 1 Secant modulus is the slope of the line between the origin and any point on the stress-strain curve. Tangent modulus is the slope at any point on the stress-strain curve and is a measure of the instantaneous rate of change of stress as a function of strain. The elastic modulus in ASTM D2105 is a tangential modulus, measuring the slope of the initial linear portion of the stress-strain curve. For guidance on the use of the elastic modulus, the user may refer to Note 9 of ASTM D2105-01.

For large diameter products, the manufacturer shall have the option of determining E_a in accordance with ASTM D638.

NOTE 2 Some winding processes are only suitable for large diameters (DN600 and greater). These processes can not be replicated in a smaller diameter suitable for testing per ASTM D2105. While ASTM D2105 is the preferred test method (since it involves testing a full section of pipe), ASTM D638 needs to be an option for certain processes.

4.4.2 Hoop tensile modulus, E_h and minor poisson's ratio, ν_{ah}

E_h and ν_{ah} shall be determined in accordance with API 15HR.

4.4.3 Major poisson's ratio, ν_{ha}

ν_{ha} shall be determined in accordance with Annex H.

4.4.4 Circumferential bending modulus, E_{hb}

E_{hb} , the circumferential bending modulus, shall be set equal to the value of E_h or shall be determined in accordance with ASTM D2412 and equation (1):

$$E_{hb} = \frac{F_c \times 1\,000 \times r^3}{\Delta y \times 6,7 \times I} \quad (1)$$

where

F_c – compressive load per unit pipe length, expressed in N/mm

Δy – pipe deflection, expressed in millimetres

r – mean pipe radius, equal to $0,5 \times D_{r,act}$ expressed in millimetres

I – moment of inertia of the pipe, $=t_{r,act}^3 / 12$, expressed in mm^3

NOTE E_{hb} will typically be larger than E_h , thus using E_h for E_{hb} should be conservative.

4.5 Optional qualification requirements

4.5.1 Electrical conductivity

Where conductive components are specified by the principal, resistivity shall be tested in accordance with clause 6.3.1. For components requiring electrical conductivity due to external charge generating mechanisms, the surface resistivity shall be 10^5 ohms or less. For components requiring electrical conductivity due to internal charge generating mechanisms, the volume resistivity shall be 10^3 ohm-meter or less.

NOTE Internal charge generating mechanisms would typically be due to pipes carrying non-conductive fluids. External charge generating mechanisms would typically be due to pipes in a hazardous area where an incendive discharge combined with the generation and accumulation of static electricity may potentially ignite a flammable atmosphere.

4.5.2 Potable water certification

When specified by the principal, piping shall comply with the requirements of the national health or certifying authorities in the country of use.

4.5.3 Impact resistance

When specified by the principal, the product shall be tested for impact resistance. The test procedure and acceptance criteria shall be agreed between the manufacturer and the principal.

4.5.4 Qualification procedure for fire performance

Products shall be assigned a fire classification code. Refer to Annex J.

4.5.5 Low temperature performance

4.5.5.1 Long term envelope data

For temperatures below -35°C , the manufacturer shall demonstrate that the product is capable of performing satisfactorily.

4.5.5.2 Elastic properties

For temperatures below -35°C , the manufacturer shall determine the elastic properties in accordance with clause 4.4 and may then interpolate between the published values.

NOTE 1 GRP materials do not undergo ductile/brittle transition at temperatures as low as -35°C , hence, there is no significant abrupt change in mechanical properties at low temperatures. However, for elastic properties, some test data has shown an increase at lower temperatures, thus the reasoning for extrapolation of elastic properties.

NOTE 2 A possible concern is that at temperatures lower than -35°C , internal residual stresses could become large enough to reduce the safe operating envelope of the piping system. While there is some recent test data at temperatures as low as -65°C , this data has not been considered in the writing of this document.

5 Requalification

Changes to a component by an amount beyond that agreed with the principal shall invalidate the component's previous qualification. Examples of changes in component design which may require requalification are defined in Table 2.

Components shall be requalified in accordance with Annex I or ASTM D2992 Section 12 (Procedure B).

NOTE The concept of requalification with ILSS and ATS as specified in Annex I is a new concept. For future product development, this method will most likely be the preferred method. However, manufacturers with existing data per ASTM D2992 will not have this option since no baseline data was generated at the time of qualification and since requalification may have already been done per ASTM D2992 Section 12. Therefore, Section 12 from ASTM D2992 needs to remain an option for requalification, even though it is a more onerous requirement than ILSS and ATS.

The qualification reports and summaries of each such revalidated component shall be amended to include reference to this revalidation and details.

Table 2 — Change in component design that may require requalification

Reinforcement	<ul style="list-style-type: none"> — reinforcement manufacturer — reinforcement type and composition — reinforcement finish (sizing) — tow tex / yield change of 25% or more (plus or minus)
Resin and adhesive	<ul style="list-style-type: none"> — resin/adhesive manufacturer — curing system change in chemistry — curing temperature change of 20% or more (plus or minus) — curing time change of 20% or more (plus or minus) — resin/adhesive grade¹ — curing system catalyst or hardener²
Internal surface ³	<ul style="list-style-type: none"> — composition — thickness
Design	<ul style="list-style-type: none"> — geometry and dimensions outside of the scaling rules — winding angle ($> \pm 5^\circ$)⁴
<p>NOTE 1 An example of a resin/adhesive grade for GRVE would be a change from a bis-A epoxy vinyl ester to a novolac-based epoxy vinyl ester.</p> <p>NOTE 2 An example of a curing system catalyst change for GRVE would be a change from MEKP (methyl ethyl ketone peroxide) catalyst to BPO (benzoyl peroxide) catalyst.</p> <p>NOTE 3 This is a requalification requirement only for those products that can not be manufactured without a liner. For example, centrifugal casting.</p> <p>NOTE 4 For thick-wall products, it is likely that the wind angle on the outside portion of the wall can change by several degrees from the wind angle on the inside portion of the wall. For thinner wall products, the tolerance on the wind angle will most likely be closer to $\pm 3^\circ$.</p>	

6 Quality programme for manufacture

6.1 General requirements

The manufacturer shall have a suitable and accredited quality management system (QMS).

All inspection, measuring and testing equipment shall be maintained and calibrated.

Refer to Table 3 for a summary of the quality programme.

Table 3 – Summary of quality programme

No	Ref.	Test Procedure	Product(s)	Generated Data	Use
1	6.2.2	Mill hydrostatic test	Pipes	N/A	
	6.2.3		Spoolpieces	N/A	
2	6.2.4	ISO 11357-2 (DSC)	Pipes, pipe+joints,fittings and flanges	T _g	Degree of cure
		Manufacturer's standard for MDSC			
		Manufacturer's standard for DMTA			
3	6.2.5	ASTM D2583	Pipes, pipe+joints,fittings and flanges (GRUP and GRVE only)	Barcol hardness	Degree of cure
4	6.2.6	ISO 1172	Pipes, pipe+joints,fittings and flanges	Glass content	Glass content
5	6.2.7		Pipes, pipe+joints,fittings and flanges	N/A	Visual inspection
6	6.2.8	ASTM D3567	Fittings and flanges	ID, mass, thickness, lay length	
		ASTM D3567	Pipes	ID, mass per unit length, t _{r,min}	
NOTE 1 Additional sizes are to be tested if the one size is not representative of all of the products.					

6.2 Quality control tests

6.2.1 General

The frequency of quality control testing is based on a specific percentage of continuous production. Continuous production is defined as:

- for continuous winding processes, the period in which there is no change in fibre type, resin, diameter and wall thickness;
- for winding on fixed mandrels, the period in which there is no change in fibre type or resin.

6.2.2 Mill hydrostatic test for pipes

For pipes with threaded joints, the mill hydrostatic test for pipes shall be conducted at a frequency of 100 % of continuous production. For pipes with other joints, the mill hydrostatic test for pipes shall be conducted at a frequency of 5% of continuous production.

For pipes, the hydrostatic test pressure shall be maintained for a minimum of 2 minutes in order to ascertain there is no leakage. For pipes with threaded joints, the test components shall have unrestrained ends. For pipes with other joints, if practical, test components shall have unrestrained ends. Test temperature shall be at ambient conditions.

The test pressure shall be:

$$1,5 \times \text{MPR}_{65} \text{ for GRE and } 1,5 \times \text{MPR}_{21} \text{ for GRUP and GRVE}$$

NOTE $1,5 \times \text{MPR}$ and $\text{MPR} / 0,67$ produce the same results with less than 1% error. $1,5 \times \text{MPR}$ is used as this is common practice.

6.2.3 Mill hydrostatic test for spoolpieces

For spoolpieces, if practical and agreed between the manufacturer and principal, the manufacturer shall conduct a mill hydrostatic test. The hydrostatic test pressure shall be maintained for a minimum of 30 minutes in order to ascertain there is no leakage. Test components shall have unrestrained ends. Test temperature shall be at ambient conditions.

NOTE 1 Generally, a spoolpiece is only practical to hydrostatically test if it has flanged ends or ends with a mechanical connection suitable for sealing (such as a threaded joint). In most applications, only a small percentage of spoolpieces can be hydrostatically tested.

The test pressure shall be the lower of

- a) $1,5 \times \text{MPR}_{65}$ for GRE and $1,5 \times \text{MPR}_{21}$ for GRUP and GRVE and
- b) the test pressure that will generate stresses less than or equal to the occasional load design envelope for the factory hydrotest loading case.

NOTE 2 The latter requirement above is due to the fact that the axial stresses, including the non-pressure bending stresses, that may occur during the test should not exceed the occasional load design envelope. It is expected that any reduction in the factory hydrotest would be 10% or less. Typically, a reduction in the factory hydrotest would be expected in larger diameter, thin-wall pipe.

6.2.4 Degree of cure

The degree of cure shall be determined at a frequency of 1 % of continuous production. The preferred method for determining the degree of cure of either the base resin or component is by measurement of the glass transition temperature. For GRUP and GRVE, the degree of cure may be determined in accordance with 6.2.5. The manufacturer may propose an alternative procedure for assessing the state of cure subject to agreement with the principal, for example from the deflection temperature under load determined in accordance with ISO 75.

The glass transition temperature (°C) shall be determined by one of the following means:

- a) DSC (differential scanning calorimetry) according to ISO 11357-2,
- b) MDSC (modulated differential scanning calorimetry) as agreed between the manufacturer and principal,
or
- c) DMTA (dynamic mechanical thermal analysis)

The manufacturer shall use the same method throughout the quality programme for manufacture.

NOTE MDSC and DMTA may be the better methods and, furthermore, MDSC is less confusing since it does not generate 3 different values. However, for the scope of ISO14692, the extra benefit from MDSC is not necessary and any of the 3 methods are acceptable.

The measured T_g shall be equal to or greater than the baseline published by the manufacturer minus 5 °C.

EXAMPLE The baseline value is 115 °C, therefore, the measured T_g shall be at least 110 °C.

6.2.5 Barcol hardness

For GRUP and GRVE, barcol hardness testing shall be determined at a frequency of 1 % of continuous production in accordance with ASTM D2583. It is recommended that a minimum of ten readings be taken on each sample. The two highest and two lowest readings may be discarded, with the remaining six to be used to calculate an average reading.

NOTE Because the material being tested is a composite, it is not uncommon for there to be a wide range between high and low readings. Factors that can affect the Barcol hardness reading include whether the tester impacts reinforcing glass, whether the tester impacts a topcoat of resin or wax or if it impacts gelcoat. A low reading may be obtained if the tester impacts surfacing veil.

If the manufacturer is already testing for the glass transition temperature, there is no requirement to additionally conduct testing for barcol hardness.

The measured barcol hardness shall be equal to or greater than the minimum baseline published by the manufacturer.

6.2.6 Glass content

The glass content (percentage of glass-reinforcement) of the reinforced wall shall be determined in accordance with ISO 1172 at a frequency of 1 % of continuous production. The range of components shall not be limited to plain pipe, but should include all components.

For filament wound components, the measured glass content shall be within +/- 6% of the baseline published by the manufacturer. For hand-lay-up components, the measured glass content shall be within +/- 7,5% of the baseline published by the manufacturer.

NOTE 1 Testing for glass content is a destructive test.

NOTE 2 The location of the test sample on the part can be agreed between the Principle and manufacturer. Or, since this is a destructive test, a special component can be made at random to confirm glass content.

6.2.7 Visual inspection

All pipes, fittings and flanges shall be visually inspected for compliance with Annex L and, if appropriate, be repaired or rejected.

6.2.8 Key component dimensions

The following dimensions shall be determined in accordance with ASTM D3567 for at least 1 % of continuous production:

- a) internal diameter, ID,
- b) for pipes, mass per unit length
- c) for fittings and flanges, mass,

- d) for fittings and flanges, laying length.
- e) for pipes, the minimum reinforced wall thickness,
- f) for fittings and flanges, the wall thickness.

NOTE 1 t_i is a nominal thickness and should be published by the manufacturer, but does not need to be measured per ASTM D3567 as a key component dimension.

For pipes and fittings, the ID shall be within the tolerances specified by the manufacturer.

For fittings, the mass shall be within the tolerances specified by the manufacturer. In addition, the mass shall be at least 90% of the value published by the manufacturer.

Instead of the mass, the manufacturer shall have the option to use a key component dimension, such as an outside diameter or cross-sectional thickness at a specified point) for quality control.

NOTE 2 Since measuring $t_{r,act}$ of a fitting is not always practical, there is no adjustment for actual versus published wall thickness as there is for pipe. The manufacturer and principal should give consideration to the mass of the fitting. If the mass of the actual fitting to be tested is more than 110% of the published mass, consideration should be given to adjusting $P_{T1\ 000,xx}$.

NOTE 3 Fittings that are manufactured from pipe sections, such as mitered elbows, can be manufactured integral with a pipe section. Thus a mass measurement is not always practical for these types of fittings.

For fittings, the laying length shall be within the tolerances specified by the manufacturer.

The minimum reinforced wall thickness shall be determined from the average of six observations, evenly spaced at 60° apart, taken at any one cross section of the pipe. The cross section shall be remote from any build up for joint reinforcement.

It is acceptable to search for, and select, the smallest observation to begin the procedure, however the remaining 5 observations shall be evenly spaced at 60 degrees based on the first observation selected.

These 6 observations shall produce an average result that meets the following requirements:

- a) The average of these 6 observations shall be greater than $t_{r,min}$ (the manufacturers stated minimum reinforced wall thickness). Individual measurements may be below the guaranteed $t_{r,min}$, but the average of the six measurements can not be.
- b) No more than 2 of the 6 observations shall be less than $t_{r,min}$.
- c) None of the 6 observations shall be less than $0,95 \times t_{r,min}$.
- d) Where a single observation is found below $t_{r,min}$, none of the 6 observations shall exceed $1,306 \times t_{r,min}$.

This procedure may be repeated at any location along the pipe length.

NOTE 4 Accurate wall thickness measurements for GRP pipes require destructive testing and can not be measured on every pipe. Filament winding and other methods have inherent variations in pipe wall thickness. This variation in pipe wall thickness can be found along a single length of pipe, between pipe from the same lot, from the same products produced from different lots, and also from a single cross section.

NOTE 5 The $1,306 \times t_{r,min}$ requirement is intended to protect against extreme variations in the pipe reinforced wall thickness at any one cross section. $1,306 = 1 / 0,875^2$.

No component shall have excessive resin, adhesive or foreign matter on the internal wall which could provide a flow disturbance or hinder the passage of specialized equipment, for example pigs. The maximum height of adhesive bead shall be limited to 10 mm or 5 % of the internal diameter, whichever is smaller.

6.2.9 Retest

Refer to Figure 4 for the procedure for retesting.

NOTE 1 For clause 6.2.2 and prescribed threaded joints, this procedure can be ignored as 100% of components with prescribed threaded joints are subject to a mill hydrostatic. For clause 6.2.3, this procedure can also be ignored as only those spoolpieces that are practical to test are tested.

NOTE 2 Clause 6.2.7 is not part of the procedure since 100% of all components are visually inspected.

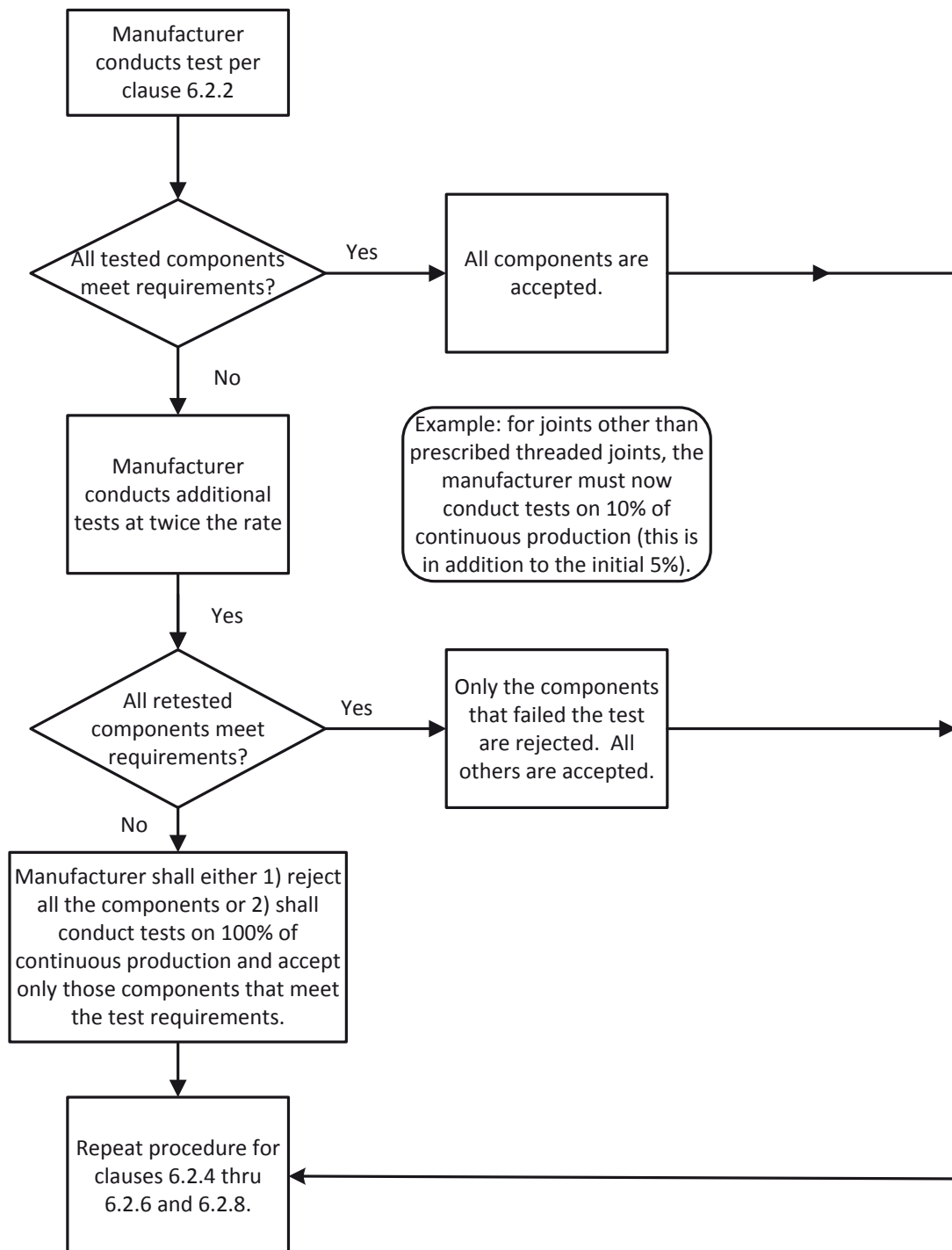


Figure 4 – Retest procedure

6.3 Optional quality control tests

6.3.1 Electrical conductivity per length

Electrical conductivity shall be determined in accordance with Figure 5. The range of components shall not be limited to plain pipe, but should include all component types, including joints, that are being produced by the manufacturer.

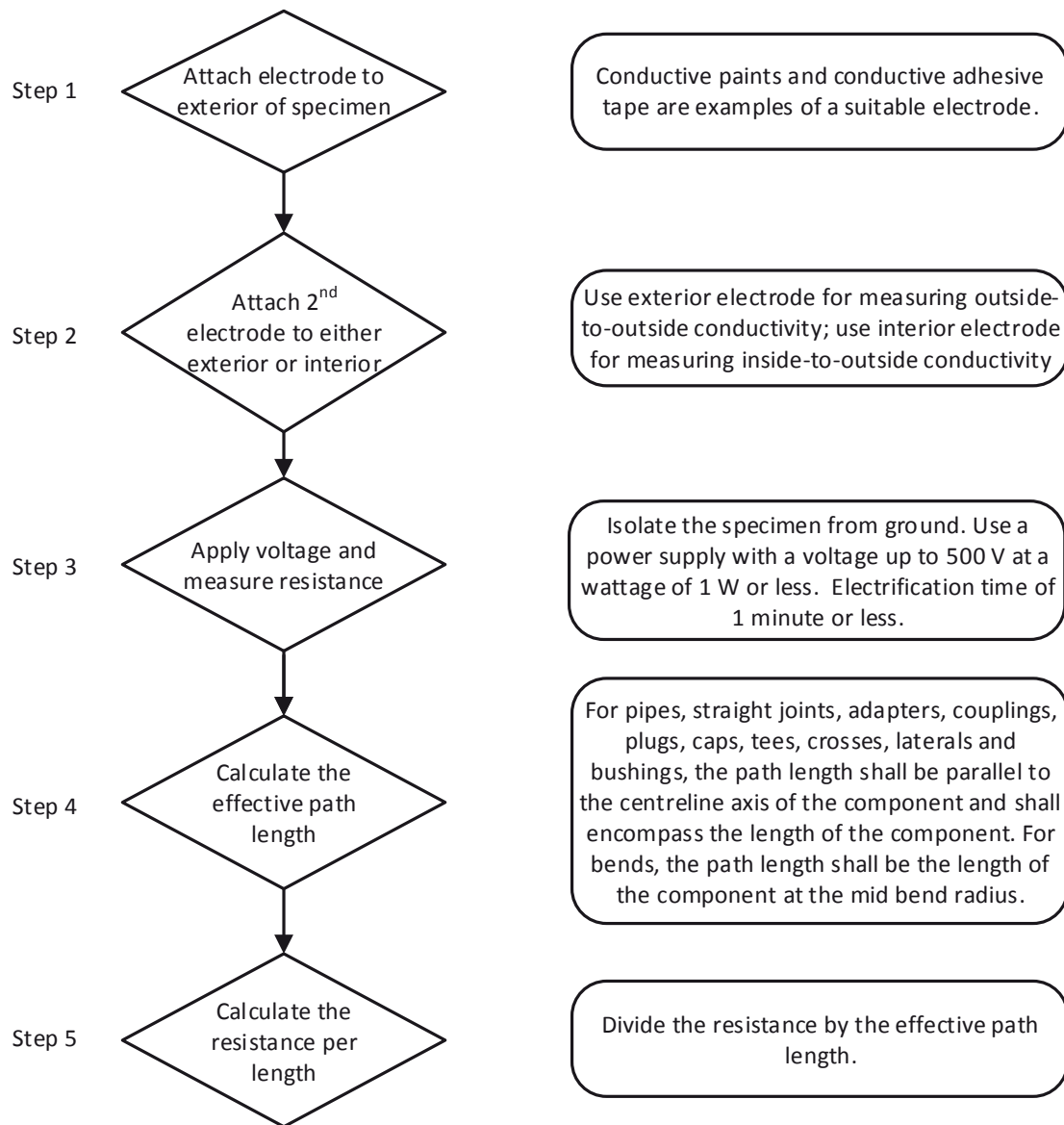


Figure 5 – Electrical conductivity test procedure

6.3.2 Fire performance

Any frequency of fire endurance, surface spread of flame / heat release and smoke obscuration / toxicity tests shall be conducted to the satisfaction of the authority having jurisdiction.