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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: Conformité aux exigences de performance et fabrication

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Foreword

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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*.

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

— *Part 1: Vocabulary, symbols, applications and materials*

— *Part 2: Qualification and manufacture*

— *Part 3: System design*

— *Part 4: Fabrication, installation and operation*

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.

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 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 resin — Determination of residual styrene monomer content*

ISO 6721-1, *Plastics — Determination of dynamic mechanical properties — Part 1: General principles*

ISO 7822:1990, *Textile glass reinforced plastics — Determination of void content — Loss on ignition, mechanical disintegration and statistical counting methods*

ISO 10467:—[1)], *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin*

ISO 10639:—[1)], *Plastics piping systems for water supply, with or without pressure — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin*

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

1) To be published.

ISO 14692-1:2002, *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 1: Vocabulary, symbols, applications and materials*

ASTM C177, *Standard test method for steady-state heat flux measurements and thermal transmission properties by means of the guarded-hot-plate apparatus*

ASTM D257, *Standard test methods for DC resistance or conductance of insulating materials*

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 D1599, *Standard test method for resistance to short-time hydraulic failure pressure of plastic pipe, tubing, and fittings*

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

ASTM D2143, *Standard test method for cyclic pressure strength of reinforced, thermosetting plastic pipe*

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 D2925, *Standard test method for beam deflection of "fiberglass" (glass-fiber-reinforced thermosetting resin) pipe under full bore flow*

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 D4024, *Standard specification for machine made "fiberglass" (glass-fiber-reinforced thermosetting resin) flanges*

ASTM D5421, *Standard specification for contact molded "fiberglass" (glass-fiber-reinforced thermosetting resin) flanges*

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

ASTM E2092, *Standard test method for distorsion temperature in three-point bending by thermomechanical analysis*

API Spec 15HR, *Specification for high pressure fiberglass line pipe*

API Spec 5B 14th edition, *Gauging and inspection of casing, tubing, and line pipe threads*

IMO Resolution A 653(16), *Recommendation on improved fire test procedures for surface flammability of bulkhead, ceiling and deck finish materials*

IMO MSC.61(67) *International code for application of fire test procedures (FTP code)*

3 Terms and definitions

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

3.1
fire endurance property
ability of an element of the structure or component to continue to perform its function as a barrier or structural component during the course of a fire for a specified period of time

3.2
fire reaction properties
material-related properties concerned with time to ignition, surface flame-spread characteristics including smouldering and post-fire-exposure flaming, and rate of heat, smoke and toxic gas release

4 Symbols and abbreviated terms

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

5 Materials of construction and wall thickness limitations

5.1 General

Permissible materials of construction are identified in 5.2 to 5.4. These shall be qualified in accordance with the qualification programme given in Clause 6. Changes in materials of construction require components to be re-qualified in accordance with 6.2.8.

5.2 Fibre

The principal reinforcement material of the component wall shall be glass fibre, e.g. continuous and/or woven rovings. The application of this part of ISO 14692 to pipes manufactured with other reinforcement fibres shall be done with caution and in agreement with the principal.

Other types of fibre reinforcement, such as carbon or aramid fibre, may be used to provide local strengthening within fittings. Such components shall be qualified by survival tests according to 6.2.3.2.2. Use of low electrical resistivity fibres, e.g. carbon, for non-structural purposes to provide electrical conductivity shall be permitted.

NOTE 1 Glass fibre is the preferred reinforcement material because there is little information available about the long-term pressure retention, impact and fire performance of pipes manufactured from other reinforcement materials such as carbon or aramid fibre.

NOTE 2 If significant quantities of carbon are present, either as fibre or filler, it may be necessary to electrically insulate the surface of the component where it could come into contact with adjacent metal components with glass-fibre-reinforced material because of the risk of galvanic corrosion.

5.3 Resin

The manufacture of components shall be limited to thermosetting resins. Typical resins are epoxy, polyester, vinyl ester and phenolic.

NOTE 1 See ISO 14692-1:2002, Clause 6.

Caution shall be applied to the use of fillers within the resin, since these can result in differing properties compared to the base resin, which will affect the long-term performance of the pipe.

The resin shall have a glass transition temperature, T_g, that is greater than or equal to 95 °C. The T_g shall be 30 °C above the standard qualification temperature, which is 65 °C.

The qualification requirements given in this part of ISO 14692 are not applicable to pipe systems that incorporate internal thermoplastic or elastomeric liners.

NOTE 2 The use of a thermoplastic liner will result in change of the failure mode for pressure retention. Such liners also have an influence on the fire endurance and electrostatic properties of the pipe.

Thermosetting resins that incorporate fibres or other filler material may be used as a liner on the inside of the pipe to provide enhanced performance, e.g. wear resistance and electrical conductivity. The liner material shall be compatible with the service conditions.

External coatings may be used to provide thermal insulation, fire resistance or electrical conductivity. However, consideration shall be given to identifying how such coatings affect the ability to detect possible leakage paths through the wall of the component during hydrotesting, or the effect that the additional mass of external coating may have on the overall stress analysis.

5.4 Joints

5.4.1 General

The joints are often the greatest area of concern with regard to the overall integrity of the piping system. The principal types of joint are:

a) adhesive/resin for bonded/laminated joints; and

b) mechanical joints.

The requirements given in 5.4.2 and 5.4.3 apply. The manufacturer shall apply an equivalent level of qualification requirements to new jointing systems that may be developed in the future.

5.4.2 Adhesive/resin for bonded/laminated joints

The adhesive to be used in the factory or field shall be the same as that used in the qualification tests. The adhesive/laminating resin shall have properties suitable for field assembly and shall fulfil the following requirements.

a) The adhesive or laminating resin shall have a suitable viscosity for application at site temperature and humidity conditions.

b) The degree of cure shall be determined in accordance with the procedures given in 6.8.2. The following shall apply, depending on the method used to determine degree of cure:

   — the glass transition temperature, T_g, of the cured adhesive or resin shall not be less than 95 % of the minimum value quoted by the manufacturer for the adhesive or resin system, as measured in accordance with 6.8.2.2;

   — the styrene content shall be no more than 2 % (mass fraction) of resin content, as measured in accordance with 6.8.2.3;

   — the Barcol hardness shall be at least 90 % of the minimum value quoted by the supplier and agreed with the principal, as measured in accordance with 6.8.2.4.

If an alternative method has been used to determine the baseline for degree of cure, then the acceptance criteria for quality control shall be in agreement with the principal.

c) The supplier shall record the test procedures used to determine the adhesive/resin properties.

5.4.3 Mechanical joints

The manufacturer shall ensure that the materials of construction of ancillaries such as O-rings, lubricants, gaskets, mastic and locking strips are suitable for the intended service conditions.

5.5 Wall thickness limitations

The structural calculations given in this part of ISO 14692 are only valid for thickness-to-diameter ratios that are in accordance with Equation (1).

$$\left(\frac{t_r}{D}\right) \leqslant 0{,}1 \tag{1}$$

where

t_r is the average reinforced thickness of the wall, in millimetres, i.e. excluding liner and added thickness for fire protection;

D is the mean diameter, in millimetres, of the structural portion of the wall.

In order to provide sufficient robustness during handling and installation, the minimum total wall thickness, t_{min}, of all components shall be defined as:

For $D_i \geqslant 100$ mm: $t_{min} \geqslant 3$ mm (2)

For $D_i < 100$ mm: $\left(\frac{t_{min}}{D_i}\right) \geqslant 0{,}025$ mm (3)

where D_i is the internal diameter of the reinforced wall of the component, in millimetres.

For more onerous applications, for example offshore, consideration should be given to increasing the minimum wall thickness to 5 mm.

The minimum wall thickness of the pipe at the joint, i.e. at the location of the O-ring or locking-strip groove, shall be at least the minimum thickness used for the qualified pipe body. Depending on location, the system design pressure and other design factors can significantly increase the required wall thickness.

6 Qualification programme

6.1 General

The qualification programme consists of standard methods for quantifying component performance with respect to static internal pressure, elevated temperature, chemical resistance, electrostatic and fire performance properties, with optional methods for quantifying potable water, impact, low temperature and limited cyclic pressure performance.

The manufacturer is required to determine a qualified pressure p_q, see 6.2.1.1, which is related to the manufacturer's nominal pressure rating p_{NPR} by the expression given in Equation (4).

$$p_{NPR} = f_2 \cdot f_{3,man} \cdot p_q \tag{4}$$

where

f_2 is a load factor (or safety factor);

$f_{3,man}$ is a factor to account for the limited axial load capability of GRP.

NOTE 1 See 7.2 and 7.10 of ISO 14692-3:2002 for further explanation.

The manufacturer shall provide the values of f_2 and $f_{3,man}$ used to develop a purchase quotation. Values of f_2 = 0,67 and $f_{3,man}$ = 0,85 are recommended as a default.

NOTE 2 $f_{3,man}$ is based on f_3 which is not a fixed parameter and is strongly dependent on the application and qualified pressure of the material.

Components that have been subjected to qualification testing shall not be used as part of a GRP pipeline or piping system.

The qualification programme also includes testing of components in order to provide data for

a) quality control,

b) system design.

NOTE 3 For flat regression curves (see 6.2.1.1) with a regression gradient of less than 0,03 it may not be possible, due to statistical uncertainty in extrapolation, to derive p_q.

6.2 Qualification pressure and temperature

6.2.1 General

6.2.1.1 Pressure terminology and service conditions

Manufacturers shall assign all components a qualified pressure, p_q, expressed in megapascals[2)], as determined according to 6.2.2. The following service conditions apply.

a) The qualified pressure is based on a standard service life of 20 years at a temperature of 65 °C.

b) The effect of operation at other temperatures and chemical degradation from the transported medium shall be accounted for by partial factors A_1 and A_2 in accordance with 6.3.2 and 6.3.3.

c) A minimum test temperature of 65 °C is required for the regression tests and the 1 000 h survival tests.

6.2.1.2 Test requirements

The qualified pressure of all components shall be verified in accordance with the requirements described in 6.2.2. The manufacturer shall document the key factors that define the component to be qualified in accordance with 11.3. These include, but are not limited to:

a) materials of construction,

b) dimensions, including those of joints and ancillaries determined in accordance with ASTM D3567 or other suitable standard,

c) manufacturing processing conditions.

The objective of the qualification procedure is to verify the proposed qualified pressure of each component. Qualification tests are proof tests of specific representatives of a given product family and do not need to be repeated for each order or project. However, changes to any of the product family characteristics detailed in 6.2.8 shall require re-qualification.

The length of test pieces for qualification of pipes and joints shall be in accordance with ISO 10639:—, Table 14 and ISO 10467:—, Table 14.

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2) 1 bar = 0,1 MPa.

Components (fittings or joints) can be tested as either single units or, if appropriate, as assemblies made up with pipe sections in order that the combined integrity of the component and pipe are verified. All joints shall be made up in accordance with the manufacturer's instructions for field assembly as detailed in 11.5. The length of pipe needed to remove the influence of end-fittings when testing assemblies or spool pieces shall not be less than three times the mean structural diameter D of the pipe. For pipes and fittings where the diameter, D, to structural wall thickness, t_r, ratio is greater than 10, then pipe lengths shorter than three times the internal diameter may be used, with a minimum length of 150 mm. The length of pipe shall be determined from Equation (5):

$$L = \left(2 \times t_r \times D\right)^{0,5} \tag{5}$$

where

D is the mean structural diameter of the pipe, in millimetres;

t_r is the average reinforced wall thickness, in millimetres.

All qualification tests shall generally be conducted with unrestrained ends such that the full pressure-induced axial load is borne by the component. An exception is made for systems where the end loads are representative of field loadings, for example by supports. Such circumstances require special considerations, and qualification tests conducted with restrained ends shall be with agreement of the principal.

All tests specified shall be carried out by, or witnessed and certified by, an independent third-party agent approved by the principal. The qualification of each component shall be documented in both a qualification report and a summary as detailed in 11.3.2 and 11.3.3.

6.2.1.3 Component definitions

In order to keep the total test burden within acceptable limits but at the same time to control the use of test data beyond their limits of applicability, the concept of a product family and its subdivisions is used in this part of ISO 14692.

The definitions given in ISO 14692-1:2002 for **product family** (2.2.100)**, product family representative** (2.2.101), **product sector** (2.2.102)**, product sector representative** (2.2.103) and **component variant** (2.2.9) are used in order to rationalize the requirements for qualification testing.

The product family representative is the component that is taken to be representative of that particular product family, i.e. component type where all variants have the same function (e.g. plain pipe, pipe/joint, bend, etc.). For the purpose of this part of ISO 14692, product families shall include, but not be limited to

a) plain pipe,

b) pipe plus joint. The product family of pipe plus joint consists of one type of joint, to be chosen by the manufacturer. The following jointing systems shall be qualified as individual product sectors: adhesive, laminated, flange, elastomeric bell-and-spigot seal lock joint, threaded, and saddles,

c) elbows and reducers, each qualified as individual product sectors,

d) tees,

e) flanges,

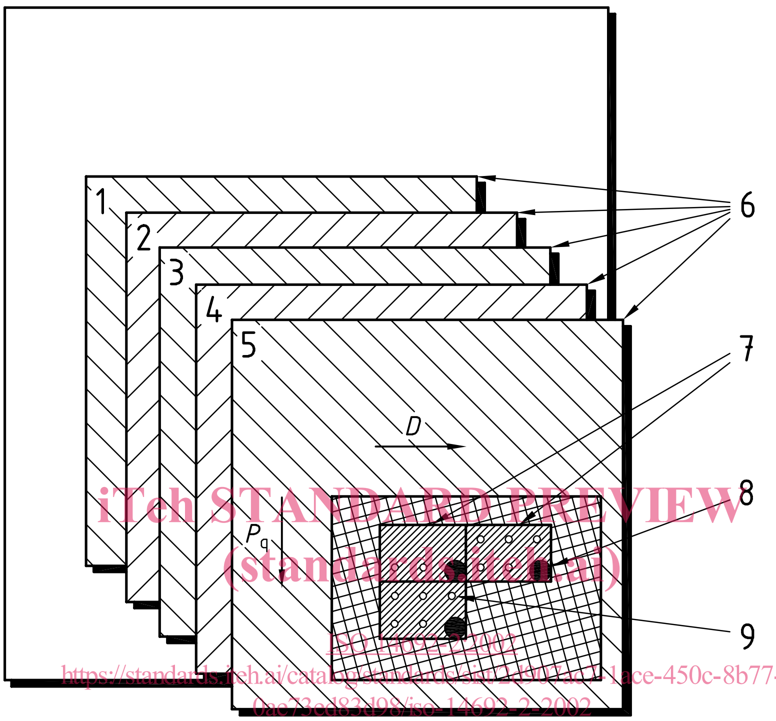
f) fabrication processes used in the factory or on-site, that are not qualified as part of the process for manufacturing stock items.

A **product sector** is a subdivision of a product family, e.g. 50 mm to 150 mm diameter plain pipe or pipe/joint for pressures less than 5 MPa (50 bar), that groups plain pipes into specific diameter and pressure ranges. A description of the breakdown of a product family into its product sectors is given in Annex A. The size of each product sector shall be limited and should closely match the example given in Table A.1 to provide

consistency of information for users. Other size ranges of product sectors with similar intervals between product sector representative diameters, e.g. as given in API Spec 15LR [12], are acceptable.

The **product sector representative** [e.g. 250 mm, 5 MPa (50 bar) pipe] for a product sector is the component variant taken to be representative of that sector and upon which the basic qualification testing is performed.

A **component variant** is an individual component [e.g. 80 mm/3 MPa (30 bar) bend, 100 mm/4 MPa (40 bar) pipe/joint, etc.].



Key

1 elbows
2 tees
3 flanges
4 joints (with pipes)
5 pipes (plain)
6 family representatives
7 product sectors
8 product sector representatives
9 component variants

Figure 1 — Breakdown of a product family into family representatives, product sectors, component variants and product sector representatives

Figure 1 schematically describes the breakdown of product range into the various definitions. A component in a product sector where the product sector representative has not been qualified may be considered qualified if the following criteria are satisfied:

a) the diameter is within 100 mm of a larger component in the adjacent product sector that has itself been qualified by testing, if the diameter of the component to be qualified is less than 400 mm;

b) the diameter is within 200 mm of a larger component in the adjacent product sector that has itself been qualified by testing, if the diameter of the component to be qualified is between 400 mm and 800 mm;

c) the diameter is within 300 mm of a larger component in the adjacent product sector that has itself been qualified by testing, if the diameter of the component to be qualified is between 800 mm and above;

d) the pressure is within 2,5 MPa (25 bar) of a component in the adjacent product sector that has itself been qualified, by testing, to a higher pressure.

6.2.2 Test methodology

The qualified pressure, p_q, for pipes, joints and fittings shall be determined in accordance with 6.2.3 to 6.2.7, where

6.2.3 describes the full qualification procedure, summarized in Table 1,

6.2.4 describes a restricted qualification procedure for low-pressure water applications,

6.2.5 describes qualification by design methods,

6.2.6 describes the further data from qualification tests required for system design (covered in ISO 14692-3),

6.2.7 describes how to translate qualified pressures from the standard design lifetime of 20 years to other design lifetimes.

The apparent ratio of the test pressure compared to the maximum possible design pressure of the component will depend on the method of qualification, see Annex B.

Table 1 — Full qualification procedure for pipes (plus joints) and fittings

Component	Product type	Qualification tests	Purpose
Plain pipe	Family representative[a]	**Full regression test** at 65 °C, or design temperature if higher (ASTM D2992:1996 – Procedure B)	Qualified pressure Qualified stress Gradient
Pipe plus joint, fittings and fabrication processes	Family representative[a]	**Full regression test** at 65 °C, or design temperature if higher (ASTM D2992:1996 – Procedure B) **or Default gradient**	Qualified pressure Baseline gradient for determining survival test pressure
	Product sector representative	Two 1 000-h survival tests at 65 °C, or design temperature if higher (ASTM D1598)	Qualified pressure
	Component variant	Two 1 000-h survival tests at 65 °C, or design temperature if higher (ASTM D1598) **or Scaling method** **or Design method** (in exceptional cases)	Qualified pressure

[a] Only one size of component diameter is required to be tested.

6.2.3 Full qualification procedure

6.2.3.1 Plain pipe qualification (family representative)

This regression qualification procedure determines the long-term hydrostatic pressure (p_{LTHP}) and lower confidence limit (p_{LCL}) in megapascals[1)] of the family representative for plain pipe based on a design life of 20 years. The gradient of the regression curve may also provide input to Table 2 if required. Only one size of pipe diameter is required to be tested. It is permissible for the manufacturer to test a pipe that includes a joint, of his choosing, since the gradient is likely to be more conservative than plain pipe. The qualified pressure, p_q, is equal to the p_{LCL}.