

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

Part 2: Qualification and manufacture

The European Standard EN ISO 14692-2:2002 has the status of a
British Standard

ICS 75.200; 83.140.30

National foreword

This British Standard is the official English language version of EN ISO 14692-2:2002, including Technical Corrigendum March 2006. It is identical with ISO 14692-2:2002.

The UK participation in its preparation was entrusted by Technical Committee PSE/17, Materials and equipment for petroleum, petrochemical and natural gas industries, to Subcommittee PSE/17/-/6, Processing equipment and systems for petroleum, petrochemical and natural gas industries, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Engineering Sector Policy and Strategy Committee, was published under the authority of the Standards Policy and Strategy Committee on 14 January 2003

Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to vi, pages 1 to 86, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments
16390 Corrigendum No. 1	31 August 2006	Changes to page 25, 6.8.2.2 and to page 49, D.2 .

© BSI 2006

ISBN 0 580 41053 6

English version

**Petroleum and natural gas industries - Glass-reinforced plastics
(GRP) piping - Part 2: Qualification and manufacture (ISO
14692-2:2002)**

Industries du pétrole et du gaz naturel - Canalisations en
plastique renforcé de verre (PRV) - Partie 2: Conformité
aux exigences de performance et fabrication (ISO 14692-
2:2002)

This European Standard was approved by CEN on 2 December 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Foreword

This document (EN ISO 14692-2:2002) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum and natural gas industries" in collaboration with Technical Committee CEN/TC 12 "Materials, equipment and offshore structures for petroleum and natural gas industries", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2003, and conflicting national standards shall be withdrawn at the latest by June 2003.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

NOTE FROM CMC The foreword is susceptible to be amended on reception of the German language version. The confirmed or amended foreword, and when appropriate, the normative annex ZA for the references to international publications with their relevant European publications will be circulated with the German version.

Endorsement notice

The text of ISO 14692-2:2002 has been approved by CEN as EN ISO 14692-2:2002 without any modifications.

INTERNATIONAL STANDARD

ISO
14692-2

First edition
2002-12-15

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



Content

Page

Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	3
4 Symbols and abbreviated terms	3
5 Materials of construction and wall thickness limitations	3
5.1 General	3
5.2 Fibre	3
5.3 Resin	3
5.4 Joints	4
5.5 Wall thickness limitations	5
6 Qualification programme	5
6.1 General	5
6.2 Qualification pressure and temperature	6
6.3 Effect of temperature and chemical resistance	16
6.4 Optional qualification requirements	17
6.5 Fire performance	18
6.6 Electrical conductivity and electrostatic dissipative properties	21
6.7 Additional component properties	24
6.8 Component data for quality control baseline	25
7 Preferred dimensions	26
7.1 Nominal diameters	26
7.2 Bend radii	27
7.3 Fitting lengths	27
8 Quality programme for manufacture	27
8.1 General requirements	27
8.2 Quality control equipment	28
8.3 Quality control tests	28
8.4 Quality control records	34
9 Component marking	35
9.1 General	35
9.2 Requirements	35
10 Handling, storage and transportation	36
11 Documentation	36
11.1 General	36
11.2 Purchase order documentation	36
11.3 Qualification documentation	36
11.4 Production quality control documentation	37
11.5 Installation documentation	38
11.6 Published values	38
Annex A (informative) Examples of component requirements for qualification	41
Annex B (informative) Pressure qualification test ratios	43
Annex C (normative) Failure envelope	46

Annex D (informative) **Guidance on determination of partial factors A_1 and A_2 for temperature and chemical resistance** 48

Annex E (normative) **Fire endurance testing** 50

Annex F (normative) **Modifications to fire reaction test procedures** 59

Annex G (normative) **Determination of electrostatic properties of GRP pipe system components** 61

Annex H (normative) **Preferred dimensions** 72

Annex I (informative) **Example of enquiry sheet**..... 75

Annex J (informative) **Example of qualification summary form**..... 76

Annex K (normative) **Least-square method for calculating the long-term hydrostatic pressure from regression data**..... 78

Bibliography..... 86

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*.

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 distortion 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).

$$\left(\frac{t_r}{D}\right) \leq 0,1 \quad (1)$$

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:

$$\text{For } D_i \geq 100 \text{ mm: } t_{\min} \geq 3 \text{ mm} \quad (2)$$

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

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).

$$p_{NPR} = f_2 \cdot f_{3,\text{man}} \cdot p_q \quad (4)$$

where

f_2 is a load factor (or safety factor);

$f_{3,\text{man}}$ 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 $f_{3,\text{man}}$ used to develop a purchase quotation. Values of $f_2 = 0,67$ and $f_{3,\text{man}} = 0,85$ are recommended as a default.

NOTE 2 $f_{3,\text{man}}$ 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 megapascals²⁾, 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.

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):

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

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

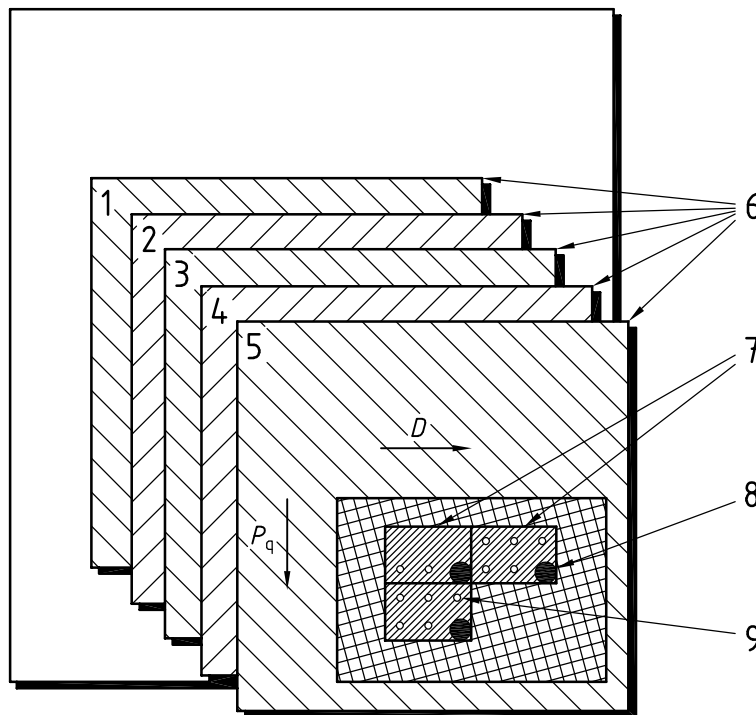
- a) plain pipe,
- b) pipe plus joint. The product family of pipe plus joint consists of one type of joint, to be chosen by the manufacturer. The following jointing systems shall be qualified as individual product sectors: adhesive, laminated, flange, elastomeric bell-and-spigot seal lock joint, threaded, 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 megapascals¹⁾ 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} .

The qualified pressure p_q or p_{LCL} are related to p_{LTHP} through equation (6):

$$p_q = p_{LCL} = f_1 \cdot p_{LTHP} \quad (6)$$

where f_1 provides a measure of the degree of scatter in the long-term pressure tests and is the evaluation of the 97,5 % confidence limit from test data as defined in ASTM D2992:1996, Procedure B.

To generate the regression curve, test details and measurement data in accordance with ASTM D2992:1996 are required. The analysis of the regression data to generate the statistical parameters of the mean, variance of the curves and p_{LCL} should be carried out in accordance with annex K of this part of ISO 14692.

On agreement between the principal and manufacturer, the analysis of the regression data may also be carried out according to ASTM D2992:1996.

NOTE ASTM D2992:1996 contains an error in Equation A1.21 where a factor 2 is missing. The equation should read $\sigma_\varepsilon^2 = 2\lambda\sigma_\delta^2$.

Testing shall be carried out on product with a diameter of 50 mm or larger at, as a minimum, 65 °C or design temperature (if higher than 65 °C). Additional testing may be carried out at other temperatures as required (see 6.3.2). The test procedure to generate the regression curve for the family representative shall be performed or witnessed by a recognized third-party approved by the principal.

The manufacturer may carry out additional testing to determine the p_{LTHP} for the pipe under different combinations of hoop and axial stress to obtain a more comprehensive failure envelope. Further guidance of the procedure is given in Annex C.

The manufacturer shall assign a qualified stress, σ_{qs} , to the pipe in accordance with Equation (7).

$$\sigma_{qs} = p_q \times \frac{D}{2t_r} \text{ MPa} \quad (7)$$

where

p_q is the qualified pressure, in megapascals;

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

t_r is the average reinforced wall thickness, in millimetres.

6.2.3.2 Pipe plus joint qualification

6.2.3.2.1 Family representative

This qualification procedure determines the gradient G , in megapascals per hour, of the family representative for pipe plus joint, see NOTE. The gradient G is used to determine the p_{LCL} based on a design life of 20 years for the product sector representative of the pipe plus joint (6.2.3.2.2). The qualified pressure, p_q , is equal to the p_{LCL} .

NOTE The primary purpose of the joint in this test is to provide a stress concentration on the parent pipe. Therefore the type of joint is less important than the presence of the joint itself.

Experience shows that failure usually occurs in the parent pipe material adjacent to the joint. Only failures in the parent pipe and not the joint shall be included in the regression analysis.

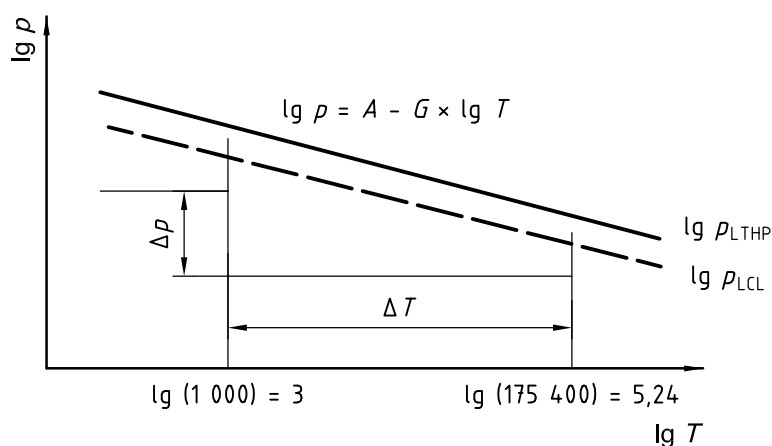
To generate the regression curve, the test details and measurement should be in accordance with 6.2.3.1. In the absence of data for the product family representative, a conservative or default gradient, G_{default} , may be used. Default gradients are listed in Table 2 and are based on experience and amount of relevant material data. The default gradient shall only be used for design temperatures up to 65 °C.

Table 2 — Default gradients

G_{default} Plain pipe having regression line with a slope $< 0,06$	G_{default} Plain pipe having regression line with a slope $> 0,06$ but $< 0,075$	G_{default} Plain pipe having regression line with a slope $> 0,075$
0,075	0,100	0,125
NOTE The unit of gradient is pressure per time. Since the scale is logarithmic, whether the units of measurement are in bar or MPa does not affect the value.		

6.2.3.2.2 Product sector representative

This qualifying procedure permits qualification of the p_{LCL} of the product sector representative based on a design life of 20 years for pipe plus joint based on a 1 000 h survival test. Each type of jointing system shall be qualified as individual product sector, i.e. adhesive, laminated, flange, elastomeric bell-and-spigot seal lock joint, threaded, saddles, etc. The objective of this procedure is to demonstrate that the product sector representative's performance is equal, or superior, to that of the family representative. The qualified pressure, p_q , is equal to the p_{LCL} .



$$\lg (T_{\text{P1 000}}) = \Delta p + \lg (p_{\text{LCL}})$$

$$T_{\text{P1 000}} = p_{\text{LCL}} \times 10^{\Delta p}$$

$$\Delta p = G \times \Delta T$$

$$= G \times [\lg (175\,400) - \lg (1\,000)]$$

$$= 2,24 \times G$$

$$T_{\text{P1 000}} = p_{\text{LCL}} \times 10^{2,24 \times G}$$

NOTE 20 years is approximately equivalent to 175 400 h.

Figure 2 — Calculation procedure for the 1 000 h test pressure

The 1 000 h test pressure is calculated using either the gradient, G , of the family representative as described in 6.2.3.1, or the default gradient, G_{default} , as determined in 6.2.3.2.1. Two replicate samples of the product sector representative shall be selected at random and pressure-tested in accordance with ASTM D1598 at 65 °C or design temperature if higher. The product sector representative is qualified if it survives the test duration, i.e. does not leak, weep, and lose test pressure or structural integrity during the test duration. Figure 2 presents the graphical calculation of test pressure using the regression line for the product family representative. The test duration shall be 1 000 h, but the manufacturer may carry out testing to a longer test duration and lower test pressure commensurate with the calculation procedure given in Figure 2.

NOTE A longer test duration may be desirable if the gradient of the component is significantly steeper than that of the plain pipe.

The 1 000 h test pressure, $T_{P1\ 000}$, in megapascals, is calculated from G and is given by Equation (8):

$$T_{P1\ 000} = p_{LCL} \times 10^{2,24 \times G} \quad (8)$$

If the default gradient, G_{default} , is used to determine the 1 000 h test pressure, then the ratio between the 1 000 h test pressure and the p_{LCL} is given in Table 3.

Table 3 — Ratio of $T_{P1\ 000}$ hour test to p_{LCL}

$T_{P1\ 000}/p_{LCL}$		
$G_{\text{default}} = 0,075$ MPa (bar)/h	$G_{\text{default}} = 0,1$ MPa (bar)/h	$G_{\text{default}} = 0,125$ MPa (bar)/h
0,147 (1,47)	0,167 (1,67)	0,191 (1,91)
NOTE See Table 2 for explanation of default gradient		

6.2.3.2.3 Component variant

This qualifying procedure permits qualification of the p_{LCL} of a component variant for pipe plus joint (same joint type as the product sector representative) based on either a 1 000 h survival test or scaling methods. The objective of this procedure is to demonstrate that the component variant's performance is equal or superior to that of both the product sector representative and the family representative. The qualified pressure, p_q , in megapascals, is equal to the p_{LCL} based on a design life of 20 years.

It is the responsibility of the manufacturer to quote the qualified pressure, p_q , i.e. the p_{LCL} of the component variant, and verify through 1 000 h survival testing that quoted value. The 1 000 h test pressure procedure calculated using either the gradient, G , or the default gradient, G_{default} , is described in 6.2.3.2.2. Alternatively, the component variant may be qualified by scaling the results of the product sector representative using the mean diameter of reinforced wall and the reinforced wall thickness of the pipe. However, only components that have a smaller diameter than the product sector representative shall be scaled using this method.

The $(p_q)_{cv}$ of the component variant is given by Equation (9):

$$(p_q)_{cv} = (p_q)_{psr} \times \left(\frac{D}{t_r} \right)_{psr} \times \left(\frac{t_r}{D} \right)_{cv} \quad (9)$$

where

$(p_q)_{cv}$ is the qualified pressure of the component variant, in megapascals;

$(p_q)_{psr}$ is the qualified pressure of the product sector representative, in megapascals;

D is the mean diameter of the reinforced wall of the component, in millimetres;

t_r is the average reinforced wall thickness of the component, in millimetres.

6.2.3.3 Fittings and qualification of other fabrication processes

6.2.3.3.1 Family representative

This qualification procedure determines the gradient G of the family representative for the fitting, e.g. bend, tee, reducer or site-fabrication process. Alternatively, the gradient G of the pipe and joint as described in 6.2.3.2.1 may be used. The minimum gradient for fittings or other site-fabrication processes is set to 0,03 irrespective of the gradient of the pipe and joint.

NOTE The latter option assumes that the joint is the most likely source of failure of the fitting during regression testing.

The qualified pressure, p_q , is equal to the p_{LCL} based on a design life of 20 years. To generate the regression curve, the test details and measurement should be in accordance with 6.2.3.1. In the absence of data for the product family representative, a conservative or default gradient, G_{default} may be used. Default gradients are listed in Table 2. The default gradient shall only be used for design temperatures up to 65 °C.

6.2.3.3.2 Product sector representative

This qualifying procedure permits qualification of the p_{LCL} of the product sector representative for the component based on a 1 000 h survival test. The qualified pressure p_q is equal to the p_{LCL} based on a design life of 20 years. The objective of this procedure is to demonstrate that the product sector representative's performance is equal, or superior, to that of the family representative. It is the responsibility of the manufacturer to quote the p_{LCL} of the product sector representative and verify that quoted value through 1 000 h survival testing in accordance with the procedure given in 6.2.3.2.2. The 1 000 h test pressure shall be calculated using either the gradient, G , of the family representative or the default gradient, G_{default} , as described in 6.2.3.3.1.

6.2.3.3.3 Component variant

This qualifying procedure permits qualification of the p_{LCL} of a component variant (same type as the product sector representative) based on either a 1 000 h survival test or scaling methods. The qualified pressure, p_q , is equal to the p_{LCL} based on a design life of 20 years. The objective of this procedure is to demonstrate that the component variant's performance is equal, or superior, to that of both the product sector representative and the family representative.

It is the responsibility of the manufacturer to quote the qualified pressure p_q , i.e. the p_{LCL} of the component variant, and verify through either 1 000 h survival testing or design calculations that quoted value. The 1 000 h test pressure procedure calculated using the default gradient, G_{default} , is described in 6.2.3.2.2. Alternatively, the scaling method qualification procedure may be used as described in 6.2.3.2.3.

6.2.3.3.4 Flanges

Flanges shall be qualified according to either of the following:

- procedures given in 6.2.3.3.1, 6.2.3.3.2 and 6.2.3.3.3 using higher rated gaskets and seals as applicable, provided they are of the same type as specified during service;
- ASTM D4024 for reinforced-thermosetting-resin flanges other than contact-moulded flanges or ASTM D5421 for contact-moulded flanges.

The method of qualification shall be agreed with the principal.

6.2.4 Restricted qualification procedure for low-pressure water applications

For low-pressure water service applications, the following qualification procedure based on the short-term burst tests may be applied. Low pressure based on the qualified pressure is defined as a function of diameter in Table 4.

Table 4 — Low-pressure application as a function of diameter

Pipe diameter mm	Qualified pressure MPa (bar)
25 to 600	1,2 (12)
600 to 1 200	0,6 (6)
> 1 200	0,3 (3)

This procedure permits qualification of a product sector representative or component variant's qualified pressure p_q based on its p_{STHP} .

The option makes a conservative estimate of the qualified pressure p_q based on the p_{STHP} and an empirical de-rating factor, Z . The p_{STHP} , in megapascals, of the component variant shall be determined using either of the following two methods:

- by testing five replicate samples in accordance with ASTM D1599. The p_{STHP} of the representative product shall be taken as the lower deviated (two standard deviations) value of the five replicate samples;
- by taking 85 % of the lower of two replicate samples tested in accordance with the test procedures given in ASTM D1599.

Testing shall be at SLT (Standard Laboratory Temperature). The rated temperature for a component qualified by this option shall not exceed 65 °C. See also 5.3 with respect to minimum required resin T_g .

NOTE Experience shows that burst-testing at SLT gives a conservative result as compared to that at 65 °C.

The qualified pressure, p_q , in megapascals, shall satisfy the criterion in Equation (10):

$$p_q = \frac{p_{STHP}}{Z} \quad (10)$$

Values of Z shall be taken from Table 5. These values are based on experience, manufacturing process, amount of relevant material data and chosen default regression gradient. See Table 2 to determine default gradient.

Table 5 — Values for empirical factor Z (up to 65 °C only)

$G_{\text{default}} = 0,075$	$G_{\text{default}} = 0,1$	$G_{\text{default}} = 0,125$
2,68	3,35	4,02

6.2.5 Qualification using design methods

For certain component variants, it may be impractical to qualify the component using the test methods given in 6.2.3 and 6.2.4 because of the proportionally high unit cost of the component.

For limited applications, components may be qualified using design methods proposed by the manufacturer. Design methods shall be checked and approved to the satisfaction of the principal.

6.2.6 Further data required for system design

For pipes, joints and fittings, the manufacturer shall assign a value r for the short-term biaxial strength ratio to the family representative. This value of r is required for system design in ISO 14692-3 and is defined as:

$$r = 2 \times \frac{\sigma_{sa(0:1)}}{\sigma_{sh(2:1)}} \quad (11)$$

where

$\sigma_{sh(2:1)}$ is the short-term hoop strength, in megapascals, which shall be calculated according to Equation (12):

$$\sigma_{sh(2:1)} = p_{STHP} \times \frac{D}{2t_r} \quad (12)$$

where

D is the mean diameter of the reinforced wall of the family representative, in millimetres;

t_r is the average reinforced wall thickness of the family representative, in millimetres;

p_{STHP} is the short-term hydrostatic test pressure, in megapascals, determined in accordance with the method given in 6.2.4;

$\sigma_{sa(0:1)}$ is the short-term axial strength in megapascals, of the component, manufactured with no liner, determined using either of the following two methods:

- by testing five replicate samples in accordance with ASTM D2105 at SLT. The $\sigma_{sa(0:1)}$ of the family representative shall be taken as the lower deviated (two standard deviations) value of the five replicate samples;
- by taking 85 % of the lower of two replicate samples tested in accordance with the test procedures given in ASTM D2105 at SLT.

For some fittings, it is not practicable to determine a value of r by testing, and the manufacturer should assign a value according to the principles given in 7.11.4 of ISO 14692-3:2002.

6.2.7 Design lifetimes other than 20 years

The standard or default lifetime of components for this part of ISO 14692 is 20 years. To convert the qualified pressure, p_{LCL} (20 years), as derived in this qualification procedure to a qualified pressure at a different lifetime, p_{LCL} at T years, use is made of Equations (13) and (14):

$$p_{LCL} (20 \text{ years}) = p_{LCL} (T \text{ years}) \times 10^{\Delta p} \quad (13)$$

$$\Delta p = G \times [1,3 - \lg(T)] \quad (14)$$

where G is the appropriate gradient of the regression line, megapascals per hour, for the component variant of interest.

6.2.8 Requalification

6.2.8.1 General

Changes to a component by an amount beyond that agreed with the principal shall invalidate the component's previous qualification, as defined in accordance with 6.2.1.2 and 6.2.1.3. Examples of changes in component design which require requalification are defined in Table 6.

Components shall be requalified in accordance with the requirements of 6.2.3.2.2, 6.2.8.2 and 6.2.8.3. If the performance is outside limits, then the modified component shall be deemed to be a new product and it shall be qualified in accordance with 6.2.3. If components have been qualified by short-term burst testing, the requalification shall be in accordance with 6.2.4 in place of 6.2.3.2.2. The p_{STHP} of the requalified component shall not be less than the p_{STHP} established in qualification testing.

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

6.2.8.2 Systematic changes to all product sectors

If a change as defined by Table 6 has been made systematically to all product sectors, then the qualification of those product sectors shall be group-revalidated by requalifying a single product sector representative for each product family, e.g. bend or joint, to be proposed by the manufacturer and agreed with the principal in accordance with 6.2.3.2.2.

6.2.8.3 Changes to a single product sector

If a change as defined by Table 6 has been made systematically to all previously qualified component variants of a particular type in a product sector, then the qualification of those variants may be group-revalidated by requalifying the product sector representative (i.e. of that type and product sector) in accordance with 6.2.3.2.2.

Table 6 — Changes in component design requiring requalification

Reinforcement	— reinforcement manufacturer — reinforcement manufacturing process — reinforcement type and composition — reinforcement finish (sizing) — filament diameter — tow tex
Resin and adhesive	— resin/adhesive manufacturer — curing system supplier — quantity and type of fillers and additives, e.g. for electrical conductivity — curing temperature — curing schedule — resin/adhesive grade — curing system type
Internal surface	— composition — curing schedule/temperature — thickness
Design	— geometry and dimensions, including that of the jointing detail — winding angle ($> \pm 5\%$) — reinforcement mass — mass fraction ($> \pm 5\%$)
Manufacturing plant	— transfer of manufacture of a qualified product from one plant to another

6.3 Effect of temperature and chemical resistance

6.3.1 General

The manufacturer shall provide partial factors, A_1 and A_2 , which respectively account for the reduction in performance capability caused by long-term exposure to temperatures above 65 °C and chemicals other than water.

The procedures for determining A_1 and A_2 are given in 6.3.2 and 6.3.3.

6.3.2 Partial factor for temperature

The manufacturer shall provide partial factor A_1 as a function of temperature. This shall take account of the effect of temperature on ancillaries such as O-rings, locking strips, etc. where applicable.

Generally pipe components qualified in accordance with 6.2 shall be qualified for operation at all temperatures, up to and including 65 °C, and A_1 shall be equal to 1,0.

If additional regression data measured in accordance with ASTM D2992 are available at temperatures other than 65 °C, it shall be permissible to interpolate between the two sets of data to determine the partial factor A_1 .

NOTE Under some circumstances, for example where data are obtained at temperatures less than 65 °C, it may be possible for A_1 to exceed 1,0.

The maximum allowable design temperature shall be less than the T_g of the resin used in the qualified component. The difference between allowable design temperature and T_g is specified in 6.8.2.2.

Guidance on alternative means for determining partial factor A_1 is given in Annex D. The method for determining partial factor A_1 shall be agreed with the principal.

6.3.3 Partial factor for chemical resistance

A suitable means for quantifying the reduction in performance is by carrying out regression testing according to ASTM D2992 with the chemical medium at the design temperature. However, this may not be practicable; if so, partial factor A_2 has to be determined by other means. Guidance on alternative means for determining partial factor A_2 is given in Annex D. The method for determining partial factor A_2 shall be agreed with the principal.

6.4 Optional qualification requirements

6.4.1 General

In addition to the qualification requirements of 6.2, components shall also be qualified for the following requirements when specified by the principal.

6.4.2 Potable water certification

Piping shall comply with the requirements of the national health or certifying authorities in the country of use.

6.4.3 Impact resistance

The manufacturer shall demonstrate that the pipe is capable of withstanding the impact from a low velocity 5 J impact representative of a dropped tool. There shall be no leakage of water when the pipe is subject to a 1 000 h survival test.

The size of the pipe shall be the same as that of the family representative originally qualified. The test shall be carried out under the following conditions:

- a) 1 m length of empty pipe, i.e. not filled with liquid, laid on a firm flat surface;
- b) a weight of 0,5 kg with a hemispherical indenter geometry of radius 12 mm shall be dropped from 1 m height;
- c) the pipe shall then be subjected to the 1 000 h survival test in accordance with 6.2.3.2.2.

6.4.4 Low temperature performance

The manufacturer shall demonstrate that the pipe is capable of performing satisfactorily at low temperatures. Both qualification as well as additional mechanical tests should be considered and agreed with the principal.

6.4.5 Limited cyclic qualification testing (7 000 cycles)

The ability of components nominally qualified for static pressure ratings to also withstand limited cyclic service shall be demonstrated by limited cyclic pressure-testing of their representative product.

In this qualification test, two replicate samples shall be tested under nominally identical pressure loadings. Testing shall be at SLT ($23\text{ °C} \pm 2\text{ °C}$). The test fluid may be water. The results may be reported alone, or included in the qualification report.

Wherever practicable, the standard cycling rate of (25 ± 2) cycles per minute as per ASTM D2143 shall be used. If this cannot be maintained then a slower rate is acceptable, so long as the actual rate used is monitored and recorded in the qualification test report. Each test pressure cycle shall range between not more than 10 % and not less than 90 % of the qualified pressure, p_q , agreed with the principal. A failure within 7 000 pressure cycles is unacceptable.

6.5 Fire performance

6.5.1 General

Fire performance is characterized in terms of the following properties:

- a) fire endurance (see 3.1);
- b) fire reaction (see 3.2).

All fire testing, if required, shall be conducted on each piping material system. If appropriate, the testing shall take account of the effect of weathering and ageing on the fire performance of the pipe, particularly if coatings are used to provide fire protection.

The performance of piping systems shall be qualified in accordance with the procedures given in 6.5.5 and 6.5.6 and assigned a classification code in accordance with 6.5.2. The fire testing shall be performed at a nationally accredited laboratory that is acceptable to the authority having jurisdiction to verify that the results for all the relevant performance parameters have achieved the defined test standards.

6.5.2 Fire classification code

The fire performance of a pipe system shall be defined according to the fire classification code A-B-C/xxx- (D-E), see also F.7 of ISO 14692-3:2002, in terms of service conditions, severity of fire threat and duration.

The fire endurance classification code is designated by a three-field number A - B - C as given in Table 7, where service function A, fire type B and integrity C are assigned prescribed levels in decreasing order of severity. For completeness, the fire classification code includes some service conditions, A, which may be outside the scope of this part of ISO 14692.

The /xxx parameter is the duration over which the pipe is qualified to function under the fire and service conditions.

The fire reaction classification code is designated by a two-field number as given in Table 8, where spread of fire and heat release D, and smoke and toxicity E, are assigned prescribed levels in decreasing order of severity.

6.5.3 Manufacturer and system identification

Any testing performed shall include the full description of the manufacturer's name and unique product code, including any details of fire protection applied.

6.5.4 Requalification

Changes to the design pressure, joint or fitting design and other generic properties of a component, e.g. fire-protection coating, resin type, wall thickness, fibre volume fraction, lay-up angle, etc. as defined in Table 6 shall invalidate the component's previous qualification.

Such components shall require requalification in accordance with 6.5.5 or 6.5.6.

6.5.5 Fire endurance tests

Pipe components shall be tested in accordance with Annex E at an independent third-party laboratory, acceptable to the authority having jurisdiction. This applies to all pipe, fittings, system joints intended to be used (including joints between non-metal and metal pipes and fittings), methods of joining, and any internal or external liners, coverings and coatings required to comply with the performance criteria.

The test conditions and size of pipe components to be tested shall be in agreement with the principal and authority having jurisdiction. Further guidance on size of pipe component to be tested and the factors that determine fire test requirements is given in E.7 and Annex F of ISO 14692-3:2002.

Tested components shall be assigned a fire classification code in accordance with Table 7.

NOTE The fire test procedures given in Annex E are consistent with the IMO type testing requirements given in [1].

6.5.6 Fire reaction tests

6.5.6.1 General

If GRP systems are fabricated from a generic type of material, it is sufficient to test the material rather than complete assemblies. Pipe components shall be tested at an independent third-party laboratory, acceptable to the authority having jurisdiction. Testing need not be conducted on every pipe size.

Testing should be conducted on piping sizes with the maximum and minimum wall thicknesses intended to be used. This will qualify all piping sizes for a specific piping material, provided that the wall thickness falls within the tested range.

6.5.6.2 Surface spread of flame and heat release

Surface spread of flame and heat release shall be evaluated in accordance with IMO Resolution A653(16) modified in the manner of F.1 to take account of the curved surface of the pipe.

6.5.6.3 Smoke obscuration and toxicity

Smoke emission, obscuration and toxicity shall be evaluated in accordance with Annex 1, Part 2 of IMO MSC.61(67) modified in the manner of F.2 to take account of the curved surface of the pipe.

Table 7 — Classification code for fire endurance properties

A: Service (Fluid or fluid state)		B: Fire type		C: Integrity/Duration see Notes 1 and 2	
DE	Dry or empty.	JF	Jet Fire	EA	Capable of maintaining the test pressure without leakage during or after test.
DF	Initially dry/empty for minimum of 5 min followed by flowing water (linear velocity ≤ 1 m/s)	HF	Hydrocarbon Pool Fire	EB	No leakage during fire test except a slight weeping may be accepted. Capable of maintaining the test pressure after cooling without significant leakage, i.e. not exceeding 0,2 l/min for a minimum of 15 min.
ST	Stagnant water	IF	Impinging flame	EC	Minimal or no leakage ($\leq 0,5$ l/min) during fire test. Capable of maintaining the test pressure after cooling with known leakage (leakage rate per metre length of pipe to be quantified in each case)
SF	Initially stagnant for minimum of 5 min followed by flowing water (linear velocity ≤ 1 m/s)	CF	Cellulosic fire	ED	Leakage permitted ($\geq 0,5$ l/min) during fire test. Capable of maintaining the test pressure after cooling with known leakage (leakage rate per metre length of pipe to be quantified in each case)
WF	Flowing water (linear velocity ≤ 1 m/s)			EE	Leakage permitted ($\geq 0,5$ l/min) during fire test. Pressure that can be maintained after cooling with known leakage to be quantified.
FG	Flammable gas			EF	No endurance required
HL	Hydrocarbon liquid				
OC	Other chemical				
NOTE 1 The indicator for duration shows the test period in minutes, e.g. / 120: greater than 2 h.					
NOTE 2 The test pressure shall be the design pressure p_d . Where p_d is not known, the test pressure shall be $p_{d, \max}$ which is $0,67 \times p_q$, where p_q is the qualified pressure.					