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Berichtigung 1:2010-09

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Petroleum and natural gas industries –
Glass-reinforced plastics (GRP) piping –
Part 4: Fabrication, installation and operation (ISO 14692-4:2017);
English version EN ISO 14692-4:2017

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Nationales Vorwort

Der Text von ISO 14692-4:2017 wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“ der Internationalen Organisation für Normung (ISO) erarbeitet und als EN ISO 14692-4:2017 durch das Technische Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ übernommen, dessen Sekretariat von NEN (Niederlande) gehalten wird.

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

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Dieses Dokument enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“ und „in (inch)“, die in Deutschland nicht zugelassen sind. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht zugelassene Einheit	Zugelassene Einheit	Umrechnung
°F	°C	$°C = (5/9)\ (°F - 32)$
in (inch)	mm	1 inch = 25,4 mm

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 9712 siehe DIN EN ISO 9712

ISO 14692-1 siehe DIN EN ISO 14692-1

ISO 14692-2 siehe DIN EN ISO 14692-2

Änderungen

Gegenüber DIN EN ISO 14692-4:2005-07 und DIN EN ISO 14692-4 Berichtigung 1:2010-09 wurden folgende Änderungen vorgenommen:

a) neuer Abschnitt 5 „Maintenance and repair“;

b) neuer Anhang C (normativ) „Minimum training requirements for bonder, pipe fitter, spool builder, supervisor and inspector“;

c) neuer Anhang E (normativ) „Electrical conductivity and electrostatic dissipative properties“;

d) neuer Anhang F (informativ) „Guidance on inspection and NDE methods“.

Frühere Ausgaben

DIN EN ISO 14692-4: 2005-07
DIN EN ISO 14692-4 Berichtigung 1: 2010-09

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Nationaler Anhang NA
(informativ)

Begriffe, Symbole und Abkürzungen

Die Benummerung der folgenden Begriffe und Abkürzungen sind identisch mit der Benummerung in der englischen Fassung.

3 Begriffe, Symbole und Abkürzungen

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

ISO und IEC führen Terminologiedatenbanken für Normen unter den folgenden Adressen:

— IEC Electropedia: verfügbar unter: http://www.electropedia.org/;

— ISO Online Browsing Platform: verfügbar unter http://www.iso.org/obp.

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Nationaler Anhang NB
(informativ)

Literaturhinweise

DIN EN ISO 9712, *Zerstörungsfreie Prüfung — Qualifizierung und Zertifizierung von Personal der zerstörungsfreien Prüfung*

DIN EN ISO 14692-1, *Erdöl- und Erdgasindustrie — Glasfaserverstärkte Kunststoffrohrleitungen (GFK) — Teil 1: Begriffe, Symbole, Anwendungen und Werkstoffe*

DIN EN ISO 14692-2, *Erdöl- und Erdgasindustrie — Glasfaserverstärkte Kunststoffrohrleitungen (GFK) — Teil 2: Zulassung und Herstellung*

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This European Standard was approved by CEN on 22 June 2017.

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European foreword

This document (EN ISO 14692-4:2017) has been prepared by Technical Committee ISO/TC 67 "Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries" in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by NEN.

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 March 2018 and conflicting national standards shall be withdrawn at the latest by March 2018.

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

This document supersedes EN ISO 14692-4:2002.

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Endorsement notice

The text of ISO 14692-4:2017 has been approved by CEN as EN ISO 14692-4:2017 without any modification.

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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.

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

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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

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

This second edition cancels and replaces the first edition (ISO 14692-4:2002), which has been technically revised. It also incorporates the Technical Corrigendum ISO 14692-4:2002/Cor 1:2006.

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

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Introduction

The objective of this document is to ensure that installed GRP piping systems will meet the specified performance requirements throughout their service life. Main users of the document are envisaged to be the principal, fabrication/installation contractors, repair and maintenance contractors, certifying authorities and government agencies.

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

Part 4: Fabrication, installation and operation

1 Scope

This document gives requirements and recommendations for the fabrication, installation, inspection and maintenance of GRP piping systems for use in oil and natural gas industry processing and utility service applications. The recommendations apply to delivery, inspection, handling, storage, installation, system pressure testing, maintenance and repair.

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

2 Normative references

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

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

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

ISO 14692-2:2017, *Petroleum and natural gas industries — Glass-reinforced plastics (GRP) piping — Part 2: Qualification and manufacture*

ASTM D1599, *Standard Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings*

ASTM D2583, *Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor*

API Spec 5B, 2008, *Specification for Threading, Gauging and Thread inspection of Casing, Tubing, and Line Pipe Threads*

3 Terms, definitions, symbols and abbreviated terms

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

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

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4 Fabrication and installation

4.1 Delivery, inspection and documentation of GRP piping

The quantity, MSP, nominal dimensions and relevant special requirements of all piping components and prefabricated spools shall be verified for compliance with the purchase order. Shipments of piping components that do not comply with the purchase order shall be reported to the responsible personnel and to the pipe producer for corrective actions.

All piping components shall be visually inspected in accordance with Table A.1 for damage that can have occurred during storage and shipment. Rejected components shall be replaced. If doubts concerning the extent of defects occur during inspection, a specialist approved by the principal shall perform a second inspection of the delivered items.

Adhesive bonding kits shall be inspected to ensure that the kits:

— contain all necessary materials;

— are not leaking or visibly damaged; and

— have at least six months remaining lifetime before the expiration of shelf-life.

All fire protection material shall be inspected to ensure that the original packaging is not damaged.

4.2 Handling and storage

The handling of the GRP components shall follow the requirements given in Annex B and the requirements of the pipe manufacturer.

4.3 System design documentation

The principal shall provide the installer at least with the following information:

a) operating and design parameters:

   1) design pressure;

   2) design temperature (maximum and minimum);

   3) T_g of the resin used in component manufacture;

   4) T_g of the adhesive used in component manufacture, if appropriate;

   5) MSP of each component and MSOP of each piping system;

   6) mean and maximum velocity conditions in each piping system;

   7) chemical resistance limitations, if applicable;

   8) procedures to eliminate or control water hammer and cavitation, if applicable;

   9) fire classification and location of fire-rated pipe, if applicable;

   10) conductivity classification, location of conductive pipe, earth linkage/grounding requirements and location of earthing points;

   11) criticality rating;

b) system drawings and support requirements for heavy equipment;

c) preferred locations for connection of final joint in pipe loops, if appropriate;

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d) system criticality and minimum requirements for inspection during installation.

4.4 Installer requirements

4.4.1 Personnel qualification

All pipe, fittings and related items shall be installed by qualified GRP pipe fitters, bonders or spool-builders and thereafter approved by a qualified GRP piping inspector. GRP pipe fitters and GRP piping inspectors shall be qualified according to the minimum requirements detailed in Annex C.

4.4.2 Health and safety

In general, all safety precautions set forth by the manufacturer of pipes and fittings, chemicals, etc. shall be adopted. Materials safety data sheets should always be read before commencing work.

4.5 Installation

4.5.1 General requirements

All piping components shall be installed so that they are ideally stress-free and at least not over-stressed, meaning that:

a) bending of pipes to achieve changes in direction, or forcing misaligned flanges together by over-torquing bolts is not permitted;

b) the manufacturer's recommendations for bolt-torquing sequence, torque increments and maximum bolt torque shall be followed;

c) all supports shall be installed (location and function) as per system design.

Prefabricated pipework shall be fabricated in accordance with fully dimensioned piping isometrics. Overall spool dimensions shall be sized, taking the following into consideration:

— site transport and handling equipment limitations;

— installation and erection limitations;

— limitations caused by the necessity to allow a fitting tolerance for installation ("cut-to-fit" requirements).

If shown on isometric drawings, the fabrication shall include "cut-to-fit" lengths and field joints on fabricated pieces to allow for the setting up of pipework accurately on-site between fixed points. "Cut-to-fit" lengths shall be left square and plain.

The installer shall take the following considerations into account.

a) The need to avoid overstressing of GRP components by the forced pulling of GRP pipework to facilitate alignment at joints, and particularly at flanged joints.

b) The need to prevent damage to joints when handling small-diameter thick-walled pipe, e.g. due to fire protection.

NOTE This is because the high rigidity of the pipe concentrates loading at the thinner sections of pipe wall adjacent to the joint.

c) The preferred location of the last site joint in a piping loop to ensure that necessary access is available, since this joint is often the most difficult to complete.

d) Delays caused by the time required for adhesive or laminated joints to cure without being disturbed. The scheduling of surrounding construction activities shall take into account the risk of possible disturbances to such joints.

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e) The need to provide temporary protection for installed GRP piping if risk of mechanical damage is high. The installer shall also consider correct sequencing of fabrication activities to minimize risk of damage.

f) The need to prevent overheating of the GRP pipe material by electric surface heating, if applied. Heat tracing should be loosely spirally wound onto GRP pipe in order to distribute the heat evenly around the pipe wall. Heat distribution can be improved if aluminium foil is first wrapped around the pipe.

g) Provision of suitable joints to facilitate isolation or access to the pipe for maintenance purposes.

4.5.2 Components fabricated on-site

All processes used to fabricate spoolpieces and components on-site, e.g. mitred elbows, tee pieces and laterals, shall have been qualified according to procedures given in ISO 14692-2:2017, Clause 5.

4.5.3 Cutting

GRP pipe shall be cut according to the manufacturer's instructions.

For adhesive-bonded connections, the pipe end shall be machined with a pipe shaver according to the manufacturer's recommendations.

4.5.4 Above ground application — Supports

GRP piping systems may be supported using the same principles as those for metallic piping systems. However, due to the proprietary nature of piping systems, standard-size supports do not necessarily match the pipe outside diameters. The use of saddles and elastomeric (neoprene) pads may allow the use of standard-size supports.

The following guidelines to GRP piping support shall be followed.

a) Supports in all cases should have sufficient width to support the piping without causing damage and should be lined with an elastomer or other suitable soft material.

b) Clamping forces, if applied, should be such that crushing of the pipe does not occur. Local crushing can result from a poor fit and all-round crushing can result from over-tightening.

c) In all cases, support design should be in accordance with the manufacturer's guidelines.

d) Supports should preferably be located on plain pipe sections rather than at fittings or joints.

e) Supports shall be spaced to avoid sag (excessive displacement over time) and/or excessive vibration for the design life of the piping system.

f) Valves or other heavy attached equipment shall be adequately and if necessary (as determined from system design calculations) independently supported.

g) GRP pipe shall not be used to support other piping, unless agreed with the principal.

h) Consideration shall be given to the support conditions of fire-protected GRP piping. Supports placed on the outside of fire protection can result in loads irregularly transmitted through the coating, which can result in shear/crushing damage and consequent loss of support integrity.

i) GRP piping should be adequately supported to ensure that the attachment of hoses at locations such as utility or loading stations does not result in the pipe being pulled in a manner that could overstress the material.

j) The anchor or linestop support shall be capable of transferring the required axial loads to the supporting structure without causing overstress of the GRP pipe material.

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k) Anchor or linestop clamps are recommended to be placed between two double 180° saddles, adhesive-bonded or laminated to the outer surface of the pipe. The manufacturer's standard saddles are recommended and shall be bonded using standard procedures.

4.5.5 Buried piping

The following guidelines to buried piping shall be followed.

a) In-situ conditions — an appreciation of the local soil conditions and water table should be obtained prior to trench excavation.

b) Embedment materials — the local soil type should be identified in order to determine the support that can be provided to the buried GRP pipe system. Other issues to consider include moisture content and permeability which, if inappropriately selected, could lead to improper settlement.

c) Considerations for use of soil in backfill — the soil properties should be assessed in terms of potential compaction. A too large compaction load can damage the GRP pipe.

d) Trench excavation — the trench sides should be stable under all working conditions. Excavated soil material should not be placed near the edge of the trench. Ideally, water should be removed from the trench prior to pipe laying and backfilling.

e) The minimum width of the bottom of the trench for a single pipe should be a least 1,5 times the pipe diameter. For multiple pipes, the distance between pipes should be at least 0,5 times the larger pipe diameter and the gap between the outer pipe and the trench wall should be at least the same width as for a single pipe.

f) Trench bottom — all rock, hard pan and sharp objects shall be removed.

g) Preparation of the trench — the bedding material on the trench bottom should be a least 100 mm thick and provide the correct gradation and pipe support. All localized loading should be minimized, e.g. through the presence of other subsurface structures by providing at least a 300 mm bedding or compacted backfill layer.

h) Placing and joining pipe — the GRP pipe shall be placed in the trench, such that it is uniformly supported. Extra backfill or bedding material should not be added or extra backfill should not be forced in to provide this support. All joints should be installed according to the manufacturer's installation guideline.

i) Placing and compacting backfill materials — backfill materials should be placed around the GRP pipe, such that they will not disturb or damage the pipe. The backfill material should be worked into the underside of the pipe before backfilling the trench.

j) Compacting the backfill material — the backfill material should be compacted in the trench but it should be ensured that the compacting loads will not damage the buried pipe. The minimum cover of backfill material should be such that no damage to the buried pipe is caused by surface loads, e.g. vehicle weight. . Design guidance on burial depth is provided in section 5.7.3 of AWWA Manual M45 (second edition).

k) Thrust blocks, if required, shall be capable of transferring the axial loads to the supporting structure without causing overstress of the GRP pipe system.

Further guidance on GRP buried pipe installation is provided in Clause 6 of AWWA M45:2013 (second edition) and design of thrust blocks in Clause 7 of AWWA M45:2013.

4.5.6 Tolerances

Global tolerances shall be within ±6 mm in all directions, unless otherwise shown on the approved drawings. Dimensional tolerances for finished piping are given in Table 1. The dimension numbers are shown in Figure 1.

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The acceptable tolerances for misalignment of flanges during installation are given in Table 2. It is common practice for some flanges to be manufactured with bolt holes larger than the size of bolt being used with the flange. Typically, the hole will be 3 mm larger. This should be taken into account when assessing the flange misalignment tolerance in Tables 1 and 2.

Table 1 — Maximum dimensional tolerances

Internal pipe diameter	Tolerances (relative) Dimension number (see Figure 1)					
	1	2	3	4	5	6
mm	mm	mm	° (degrees)	mm	mm	° (degrees)
25 to 200	±5	±3	±0,5	±3	±1	±0,5
250 to 300	±5	±3	±0,4	±3	±1	±0,5
350 to 400	±5	±3	±0,3	±3	±2	±0,5
450 to 600	±10	±5	±0,3	±3	±2	±0,5
700 to 900	±10	±5	±0,2	±5	±3	±0,5
1,000 to 1,200	±10	±5	±0,15	±6	±3	±0,5
1,200 to 4,000	±15	±10	±0,15	±10	±5	±1
The maximum gap shall be limited to 6 mm.						

Table 2 — Acceptable tolerances for misalignment of flanges during installation

Misalignment	Tolerances		
	Diameter range		
	50 mm to 300 mm	300 mm to 1 200 mm	1 200 mm to 4 000 mm
Flange misalignment (mm)	±1,6	±3,2	±5
Separation between spools (mm)	±2	±5	±10

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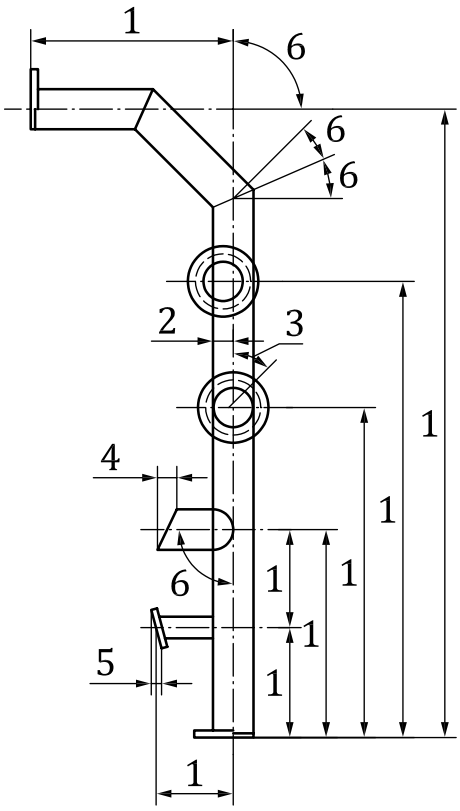

Key

1 face-to-face dimensions, or centre-to-face dimensions, or location of attachments, or centre-to-centre dimensions

2 lateral translation of branches or connections

3 rotation of flanges, from the indicated position

4 end preparations

5 cut of alignment of flanges from the indicated position, measured across the full gasket face

6 angular deflection

Figure 1 — Tolerance dimensions

4.5.7 Jointing

4.5.7.1 General requirements

All jointing shall be performed in accordance with the manufacturer's recommendations. The selection of joint type shall take into account the following:

a) the ease of access required by fitters to assemble the connection correctly;

b) the need to accommodate possible minor misalignments.

If adhesive joints are used, the installer shall ensure that the adhesive bead, which is created when the joint is made up, does not protrude significantly into the bore of the pipe. Such a protrusion can create a substantial blockage factor, as well as a source for erosion and cavitation damage. The height of adhesive bead shall be such that the maximum flow obstruction is 5 % of the inner diameter or 10 mm, whichever is smaller.

Guidance on joint type and assembly is given in Annex D.

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4.5.7.2 Quality control of adhesive and laminated joints

If so required by the principal, the following requirements shall be included for installation.

a) The frequency of hydrotesting shall be agreed between the installer and the principal.

b) The adhesive or resin used shall be in accordance with the manufacturer's recommendation and its degree of cure shall be determined according to the requirements given in ISO 14692-2:2017, Table 3.

c) The laminate surface shall be a minimum of 3 °C above the dewpoint.

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. This quoted value shall be demonstrated as an acceptable criterion from the qualification test results.

For polyester and vinyl ester resins, the residual styrene monomer content may be determined by measuring on a dummy joint made up prior to starting the jointing work. The styrene content shall be less than or equal to 2 % (mass fraction) of the resin content.

The Barcol hardness shall be measured on all laminated joints using GRV or GRUP. The number of readings shall be determined from ASTM D2583. The minimum number of readings shall be ten. The two highest and two lowest readings may be discarded, with the remaining six to be used to calculate an average reading that shall not be less than 90 % of the minimum value quoted by the manufacturer.

For small diameter pipework, the outside curvature of the pipe can make it awkward to measure consistent readings. Care is required, therefore, when measuring Barcol hardness on small diameter pipework.

4.5.8 Application of fire-protective coating

The coating should preferably be applied after hydrotesting, to facilitate inspection of possible leaks.

The application of fire-protective materials to meet requirements concerning either flame spread, smoke or toxicity shall be integral to the pipe construction. On-site application of such material shall be limited to that required for installation purposes, e.g. field joints.

If a fire-protective coating is used for the sole purpose of meeting the fire endurance requirements, the coating shall preferably be applied by the pipe manufacturer, or an approved company, at the pipe manufacturer’s location or approved company’s location. The pipes may be coated on-site in accordance with the approved procedure, subject to on-site inspection and verification.

All fire protection applied to piping components shall be subjected to the following requirements.

a) The contractor, if used, for fire-protection application shall have a quality management system and shall, in addition, have written application procedures, covering environmental control, application and inspection aspects, which are approved by the principal.

b) The following methods are acceptable for applying or covering piping components with fire protection:

   1) conventional hand application;

   2) automated process;

   3) use of moulded half-shells or sections of different shapes and lengths.

c) Before initiating fire-protection work on piping components, the contractor’s personnel intending to apply the fire insulation material shall

   1) have received training both in the application method and actual application of the fire-protection materials under the instruction of the fire-protection manufacturer,

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2) have applied fire protection to a sample pipe and fitting that is approved by the fire-insulation manufacturer and by the principal.

The contractor shall use application equipment recommended by the fire-protection manufacturer. Before fire-protection material is applied to any piping components, the surfaces shall be free from moisture, grease or any other contaminants.

After the fire-protection material is applied to the piping components, an inspection of the fire protection shall be carried out to approve or reject the work. Inspection shall include the following aspects:

— the fire-protection thickness shall be randomly measured in the cured state; the thickness shall not be less than the minimum required thickness;

— both the finish and the appearance of the fire protection shall be of the same quality as the sample submitted for approval by the fire-insulation manufacturer and the principal.

In fire-protection applications where the protection is to be removable for inspection purposes, e.g. valves and flanges, one of the following situations shall apply:

a) the fire protection shall be inside or outside a box or container so as to provide structural integrity; or

b) a complete structural reinforcing mesh integrated in the fire-protection material shall be used.

4.5.9 Electrical conductivity and electrostatic dissipative properties

If electrical conductivity requirements are specified, the installer shall verify the electrical conductivity and/or earth linkage of the piping is installed according to the requirements documented by the system designer. Further requirements are given in Annex E.

4.5.10 Earthing

If an electrostatic hazard is reported in the documentation provided by the system designer, the contents of the pipes shall be directly connected to earth by at least one exposed earthing point on the inside of the system.

The location and/or maximum distance between earthing points shall be determined from the documentation provided by the system designer.

4.5.11 Quality programme for installation

The contractor shall maintain a high level of inspection and quality assurance to ensure compliance with all requirements of this document, and shall have a quality management system.

The contractor shall designate one individual, experienced in all aspects of GRP piping field fabrication, to be responsible for quality control throughout the installation of the GRP piping system.

Quality control shall be based on the implementation of:

a) records of adhesive and lamination jointing procedure qualification;

b) requirements by the principal for inspection of all types of joints used;

c) inspection register for all types of joints used;

d) inspection of finished fabricated pipework for compliance with design drawings, within tolerances as detailed in 4.5.6.

For quality assurance and quality control during the installation phase, the principal shall have the right to inspect the ongoing work, as well as inspect the contractor's quality control routines.

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Each pipe joint shall be permanently marked for identification purposes and inspected. A log book containing key values relevant for the bonding process and inspection shall be maintained. The key values are the following:

— date;

— temperature and relative humidity;

— connection identification number;

— curing temperature and time;

— joint preparation procedure and elapsed time between surface preparation and application of adhesive;

— signature of pipe fitter and inspector;

— bolt torque;

— electrical continuity and resistance to earth, if appropriate.

Each site and field joint between pipes, fittings or flanges shall be inspected by an approved inspector as defined in 4.4.1.

It is recommended that the principal carry out hydrotesting of representative site-fabricated joints and fittings soon after the start of installation to verify the standard of workmanship irrespective of the pipe diameter.

4.6 System testing

4.6.1 Flushing

On completion of installation, GRP piping systems shall be flushed. The medium used for flushing shall be seawater or fresh water. Flushing should preferably be carried out at temperatures above 5 °C. When flushing with fresh water in sub-zero temperatures, precautions shall be taken to avoid freezing of the water in the piping system, i.e. the water should be continually circulating, or glycol antifreeze added, or the system should be drained for the duration of sub-zero temperatures.

4.6.2 Pressure testing

4.6.2.1 General

All closed GRP piping systems shall be hydrostatically pressure-tested after installation. Preferably, the system should be installed, such that smaller parts of a system can be pressure-tested separately and at the earliest opportunity during construction.

NOTE Early testing avoids having a pressure test of the entire system late in a project phase, when joint failures could have a schedule impact on project completion.

Systems that are open to atmosphere (e.g. drains) shall be subjected to a hydrostatic joint leak test.

4.6.2.2 Preparation

A formal risk assessment should be carried out prior to the hydrotest. All supports, guides and anchors shall be in place prior to pressure testing. Temporary supports and restraints shall be added based on the system design from the hydrotest load case, if required. Unless stated otherwise, all valves shall be through-body tested. Piping containing check valves shall have the source of test pressure located on the downstream side.

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All adhesive-bonded joints and laminated joints shall be fully cured prior to pressure testing. Threaded connections and the bolts of flanged joints shall be made up to the correct torque prior to pressure testing.

4.6.2.3 Testing

Field hydrotesting testing shall be carried out on all piping systems and shall involve both a strength test and a leak test.

Water shall be admitted at a low point in the system and provision shall be made for bleeding the air at high points. Any compressed air in the system can give erroneous results. Removal of air pockets prevents damage to piping and personnel in the event of an unexpected failure during the pressure test.

4.6.2.3.1 Integrity test

The purpose of the integrity test is to locate any inherent weaknesses in the piping system that could result in failure within the design life.

For process piping, the integrity test pressure shall be 1,5 times P_{des}, where P_{des} is the client-specified system design pressure expressed in MPa.

For pipelines, the integrity test pressure shall be the lower of 1,5 times P_{des}. The test condition shall be within the occasional load (f_2 = 0,89) allowable design stress envelope; however, the test pressure shall not be less than 1,25 times P_{des}.

For pipeline systems with elevation variations, the required pressure should be achieved at the system low point. However, the high point test pressure should not be less than 1,25 times P_{des}. This may result in sections with large elevation variations requiring multiple test sections.

The test pressure shall be gradually raised over a period of 30 min or longer to the required test pressure.

The integrity test shall be conducted for a minimum hold period of 2 h, during which time the test pressure shall be maintained with ±2,5 % of the required test pressure with no test fluid being added or removed during the hold period of the test.

To accommodate the effects of air adsorption, temperature change or creep test fluid may be added or removed until these conditions stabilize. The test hold period should begin once stable conditions have been achieved.

4.6.2.3.2 Leak test

The purpose of the leak test is to ensure that the piping system is leak-free at the time of the test. The leak test pressure shall be 1,1 times P_{des}. For systems with elevation variations, the required pressure should be achieved at the system low point and system high point test pressure should not be less than 1,0 time P_{des}. For large elevation variations, the system low point test pressure may be increased above the required test pressure; however, this should not exceed 1,25 times P_{des}.

The leak test minimum hold period shall be as follows:

a) for piping systems with the joints and other potential leak sources exposed for inspection:

   1) sufficient time to inspect all joints and potential leak sources;

   2) a minimum duration of 2 h;

b) for pipelines or piping systems where the joints and other potential leak sources are not exposed for inspection:

   1) sufficient time to determine by calculation or otherwise that the pipe is not leaking;

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2) a minimum 24 h, or time long enough to determine leakage by pressure drop.

Combined integrity and leak tests may be carried out at the higher integrity test pressure for plant piping and pipelines with the joints exposed. For pipelines where the joints are not exposed, a combined pressure test for 24 h should not be carried out at the higher integrity test pressure.

No test fluid may be added or removed during the leak test hold period. If test fluid is added or removed, the test hold period shall begin again.

NOTE Determining leakage by calculation is difficult due to the low E-modulus of GRE materials and the uncertainty of the temperature profile over time over the entire length of the system. The low E-modulus can cause slight creep in the system and is very difficult to predict with calculations.

If the test section pressure is falling, then a "step test" should be considered to help identify if this is due to stabilizing or due to a leak. The pressure should be raised to the required test pressure and the test section closed off. After a 30-min hold period, the pressure should be recorded and then a measured quantity of test fluid should be added to return to the required test pressure. This process of 30-min hold periods should be repeated and the following should be plotted for each interval:

a) pressure versus time;

b) pressure drop versus time;

c) test fluid volume added;

d) pressure drop divided by fluid volume added.

Rising trends on a) and d) suggest a stabilizing transient. Falling trends on b) and c) suggest a stabilizing transient. If both trends are flattening out over time, this suggests that the test section has no leaks.

For both the integrity test and the leak test, checks shall be carried out by visual inspection of the complete piping system. Any leaking or weeping shall constitute a failure and the test shall be terminated and a repair effected. The test procedure shall then be repeated. Over-torquing of flanges to stop leaks shall not be permitted. Leaking flanges shall be remade with new gaskets and retested. If leakage still occurs, flanges shall be replaced.

The system shall be considered to have passed the hydrotest if there is no leaking or weeping of water from the piping during the hold period and there is no significant pressure loss that cannot be accounted for by reasonable engineering considerations.

The following should be taken into account:

— the hydrotest condition should be fully examined as an occasional load design case;

— the hydrotest condition can, in some instances, be the critical case for determining the minimum required pipe wall thickness;

— end users who enforce a 1,5 times P_{des} hydrotest should be aware that this can lead to additional pipe wall thickness, and so costs, being required for their applications.

The following factors influence the choice of test duration:

a) effect of joint expansion and material creep, particularly when long runs of pipe are being tested;

b) water uptake properties of the GRP material, e.g. phenolic materials;

c) effect of temperature, which is noticeable when testing is performed in a climate where relatively large changes in temperature can occur during the time period of the test;

d) the length of the system being tested — longer piping systems require more time to visually inspect the system during the test, whereas short systems may require less time.

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4.6.2.4 After completion of test

Gaskets at flanged joints which have been broken for testing shall be renewed.

4.7 Certification and documentation

4.7.1 Flushing certificate

Upon completion of flushing, a flushing certificate delineating the flushing boundary limits shall be endorsed by the principal. As one flush may extend over more than one pressure or leak test, the flushes shall be numbered separately and cross-referenced on applicable test isometric drawings. A copy of the completed flushing certificate shall be incorporated into the relevant test packs.

4.7.2 Pressure test certificate

Upon completion of successful testing, a pressure test certificate showing the limits of the test shall be endorsed by the principal and incorporated into the relevant test pack.

4.8 Inspection

Visual inspection, both internally (as far as physical access allows) and externally, shall be carried out of all joints and all surfaces. An illumination source, mirrors and other suitable aids may be used to maximize the extent and accuracy of the visual inspection. Possible defects that can occur during either manufacture, installation or operation are listed in Table A.1. Acceptance criteria and corrective action are also presented. Further guidance on defect detection using NDE/NDT methods is given in Annex F. A pipe visual inspection may also include looking for signs of pipe movement near changes of diameter or pipe direction.

The presence of a uniform fillet of adhesive is an indicator that an adhesive joint has been assembled correctly.

4.9 Repair after installation

4.9.1 General

Rejected components shall, in general, be replaced by the manufacturer. After the pipe spools are installed, repair can be an alternative to replacement. The repair methods proposed by the contractor or manufacturer shall be approved by the principal.

4.9.2 Repair methods

4.9.2.1 Replacement

Pipe sections with major damage shall be replaced in accordance with procedures qualified in ISO 14692-2:2017, Clause 5. All replacement work shall be performed according to the methods and requirements covered in 4.5. Pipe fitter qualification requirements for the replacement of piping shall be identical to those for the installation of the original pipework as defined in 4.4.1.

4.9.2.2 Minor repairs

Minor repairs to pipe and fittings may be repaired on-site. Any damaged outer layer shall be ground and cleaned, and resin/hardener mix applied as recommended by the manufacturer. It is permissible to repair flanges by grinding and filling minor cracks with resin.

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5 Maintenance and repair

5.1 Maintenance

5.1.1 General

GRP pipes are generally maintenance-free, but attention shall be given to 5.1.2 to 5.1.5 during inspection.

5.1.2 Removal of scale and blockages

Care shall be taken in the use of conventional methods for removal of scale and other internal blockages (e.g. high-pressure water lances, mechanical and chemical cleaning methods). The manufacturer's recommendations shall be followed in all cases.

5.1.3 Earthing requirements

Earthed GRP piping systems shall be periodically checked to ensure that all earthing leads are functional and that the requirements for continuity of electrical path and the resistance to earth are not greater than the specification given in the system design documentation (see 4.3).

If conductive paint has been applied to the outside of the pipe, the condition of the coating shall be inspected. The maximum uncoated area on the painted surface shall be 100 cm^2. If coating has peeled away from the pipe, the coating shall be replaced in accordance with Annex E.

5.1.4 Surface and mechanical damage

The following types of damage can affect the performance of GRP pipes:

a) breakdown of outer surface (chalking) due to UV influence, which may result in exposed fibres;

b) breakdown of outer surface due to weld splatter and abrasion;

c) impact damage;

d) cracks in flanges caused by over-torqued bolts or incorrect flange design;

e) excessive pressure transients, e.g. water hammer.

The damage shall be assessed in accordance with Table A.1.

5.1.5 Fitter and inspector qualification

GRP pipe and fittings shall be repaired or replaced by qualified GRP pipe fitters and thereafter approved by a qualified GRP piping inspector. Approval shall be equivalent to fulfilment of the requirements detailed in 4.4.1.

5.2 Repair

5.2.1 General

The repair procedure shall be produced and qualified by the contractor in accordance with the GRP pipework manufacturer's recommendations and reviewed by the principal prior to implementation. It shall be demonstrated that the repair method restores the specified properties. Test methods (if appropriate) shall be agreed between the principal and manufacturer. Areas and number of repairs shall be reported and recorded.

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5.2.2 Replacement

Pipe sections with major damage shall be replaced. All replacement work shall be performed according to the methods and requirements covered in 4.5. Pipe fitter qualification requirements for the replacement of piping shall be identical to those for the installation of the original pipework (see 4.4.1).

5.2.3 Minor repairs

Minor repairs to pipe and fittings may be carried out on-site in accordance with the manufacturer's recommended procedures by qualified GRP fitters.

5.2.4 Temporary repair

Temporary repairs may be carried out as agreed by the principal. A range of techniques are available, which include, but are not limited to, adhesive-bonded saddles, laminated overwraps, tape overwraps or clamps.

The principal shall assess the suitability of these techniques according to the criticality of application and the reliability of repair.

5.2.5 Quality programme for repair and maintenance

The requirements for the quality programme for repair and maintenance shall be the same as given in 4.5.7.2. Each repair shall be permanently marked for identification purposes. A log book containing key values relevant for the repair process shall be maintained. These records should incorporate the following:

a) date;

b) temperature and relative humidity;

c) location;

d) details of maintenance work;

e) signature of pipe fitter.

5.3 Modifications and tie-ins

Modifications and tie-ins shall be considered as a new installation and be performed in accordance with requirements and recommendations contained in Clause 4.

5.4 Requirements for testing and re-certification

If repair, replacements or modification of the piping in the piping system have been made, the section containing the repaired or replaced piping shall be re-certified by performing a pressure test if appropriate or practical. The test pressure shall be as prescribed in 4.6.

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Annex A
(normative)

Defect types — Acceptance criteria and corrective actions

A summary of visible defects, along with acceptance criteria and corrective actions, is listed in Table A.1.

Major repair to major defects is defined as:

a) permanent replacement;

b) temporary laminated joint prior to permanent replacement;

c) temporary clamps or saddles prior to permanent replacement.

Minor repair to minor defects comprises on-site repair by grinding, cleaning and application of resin/hardener or laminations as recommended by the manufacturer.

Main detectable defects are regions in bonded pipe joints lacking adhesive, delaminations, voids and deviations in wall thickness.

For pipe body defects, the corrective action termed reject is defined as replace.

For female joint ends, reject is defined as replace.

For male joint ends, reject is defined as either replace or remove and re-thread.

Specification of threading, gauging and thread inspection for all threaded joints shall be in accordance with API Spec 5B. However, for non-standard API threaded connections, the dimensions and tolerances of the thread shall be according to the specifications of the manufacturer, for that product.

The column with other potential NDE methods is for information only. Few of these methods have been tested and verified or acceptance criteria set. No reference to these methods shall be made other than for study purposes.

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