INTERNATIONAL STANDARD

ISO 14692-4

Second edition
2017-08

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

Part 4: Fabrication, installation and operation

Industries du pétrole et du gaz naturel — Canalisations en plastique renforcé de verre (PRV) —

Partie 4: Construction, installation et mise en œuvre

Reference number
ISO 14692-4:2017(E)

ISO copyright office
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Contents

Page

Foreword ..... **v**

Introduction ..... **vi**

1 Scope **1**

2 Normative references **1**

3 Terms, definitions, symbols and abbreviated terms **1**

4 Fabrication and installation **2**

4.1 Delivery, inspection and documentation of GRP piping 2
4.2 Handling and storage 2
4.3 System design documentation 2
4.4 Installer requirements 3
4.4.1 Personnel qualification 3
4.4.2 Health and safety 3
4.5 Installation 3
4.5.1 General requirements 3
4.5.2 Components fabricated on-site 4
4.5.3 Cutting 4
4.5.4 Above ground application — Supports 4
4.5.5 Buried piping 5
4.5.6 Tolerances 5
4.5.7 Jointing 7
4.5.8 Application of fire-protective coating 8
4.5.9 Electrical conductivity and electrostatic dissipative properties 9
4.5.10 Earthing 9
4.5.11 Quality programme for installation 9
4.6 System testing 10
4.6.1 Flushing 10
4.6.2 Pressure testing 10
4.7 Certification and documentation 13
4.7.1 Flushing certificate 13
4.7.2 Pressure test certificate 13
4.8 Inspection 13
4.9 Repair after installation 13
4.9.1 General 13
4.9.2 Repair methods 13

5 Maintenance and repair **14**

5.1 Maintenance 14
5.1.1 General 14
5.1.2 Removal of scale and blockages 14
5.1.3 Earthing requirements 14
5.1.4 Surface and mechanical damage 14
5.1.5 Fitter and inspector qualification 14
5.2 Repair 14
5.2.1 General 14
5.2.2 Replacement 15
5.2.3 Minor repairs 15
5.2.4 Temporary repair 15
5.2.5 Quality programme for repair and maintenance 15
5.3 Modifications and tie-ins 15
5.4 Requirements for testing and re-certification 15

Annex A (normative) **Defect types — Acceptance criteria and corrective actions** **16**

Annex B (normative) **Handling and storage** **26**

Annex C (normative) **Minimum training requirements for bonder, pipe fitter, spool builder, supervisor and inspector** **29**
Annex D (informative) **Guidance for use of jointing methods** **59**
Annex E (normative) **Electrical conductivity and electrostatic dissipative properties** **68**
Annex F (informative) **Guidance on inspection and NDE methods** **70**
Bibliography **75**

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.

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.

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:

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

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

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;

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.

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.

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.

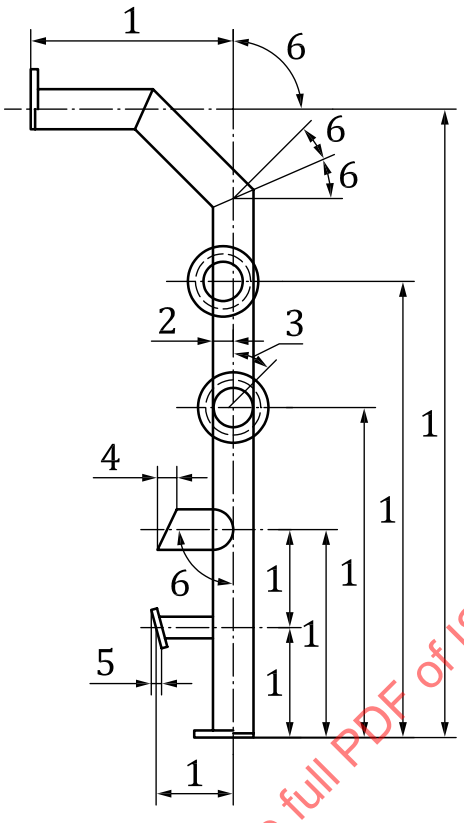
The acceptable tolerances for misalignment of flanges during installation are given in Table 2. It is common practice for some flanges to be manufactured with bolt holes larger than the size of bolt being used with the flange. Typically, the hole will be 3 mm larger. This should be taken into account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



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.

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,

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.

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.

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;

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.

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.

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.

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.

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.

Table A.1 — Defect types, acceptance criteria and recommended corrective action

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
GRP material/adhesive bonds										
Air bubbles	Voidage within laminte or outer gel coat caused by entrapped air	Poor quality manufacture	Minor effect on performance	Visual inspection	Radiography	None permitted with diameter greater than 3 mm	Reject	N/A	N/A	Minor repair if within outer gel coat
Blistering	Blisters forming under outer plies of laminate or inner resin rich layer	Poor quality manufacture	Reduced pressure to cause weepage failure	Visual inspection	Ultrasonics Radiography	None permitted	Reject	Reject	Reject/ major repair	Acceptable if no leakage
Burn/ discolouration	Thermal decomposition evidenced by distortion or discolouration of the laminate surface	Interaction with external heat source	Reduced pressure to cause weepage	Visual inspection	None	Distortion and/or burn deeper than surface resin layer	Reject (major defect)	N/A	Reject/ major repair	Reject/ major repair
						Minor discol-ouration and/or limited to surface resin layer, no extent limit	Repair (minor repair)	N/A	Minor repair	Minor repair
Chalking and loose fibres	Minor break-down of outer surface due to UV radiation	Exposure to UV radiation	Minor breakdown of outer surface	Visual inspection	None	Depth limited to surface resin layer, surface area unlimited, no loose fibres	Repair (minor repair)	Accept	Accept	Accept
						Depth limited to surface resin layer, surface area unlimited, loose surface fibres	Reject	Reject	Minor repair	Minor repair
Chemical attack	Absence of resin surface	Interaction with external chemi-cal source	Reduced pressure to cause weepage	Visual inspection	None	None permitted	Reject	Reject	Reject	Reject/ major repair
Chemical spill	Minor break-down of surface resin	Interaction with external chemi-cal source	Reduced pressure to cause weepage	Visual inspection	None	Subject to immedi-ate action	Clean, accept	Clean, accept	Clean, accept	Clean, accept

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Chip	Small piece broken from edge or surface. If reinforcing fibres are broken, damage is considered to be a crack	External impact Mishandling	Minor effect on performance	Visual inspection	None	If undamaged fibres are exposed over any area; or no fibres are exposed but an area greater than 25 mm × 25 mm lacks resin	Minor repair	Minor repair	Minor repair	Minor repair
						If no fibres are exposed and the area lacking resin is less than 25 mm × 25 mm	Accept	Accept	Accept	Accept
Crack	Actual separation of laminate, visible on opposite surfaces, extending through the wall. A continuous crack may be evidenced by a white area	External impact Mishandling Poor quality manufacture	Reduced pressure to cause weepage	Visual inspection	Ultrasonics Radiography	Maximum depth equal to or less than resin layer	Minor repair	Minor repair	Minor repair	Accept
						Maximum depth greater than resin layer	Reject	Reject	Reject/ major repair	Major repair
Crazing	Fine hairline cracks at or under surface of laminate	External impact Poor quality manufacture	Minor effect on performance	Visual inspection	None	Max. crack length less than 25 mm	Accept	N/A	Accept	Accept
						Max. crack length greater than 25 mm	Minor repair	N/A	Minor repair	Minor repair
Cut roving	Broken or cut outer rovings	Scraping, scuffing or manufacturing process	Reduced pressure to cause weepage	Visual inspection	Ultrasonics Radiography	Maximum 3 areas of cut rovings per pipe with each area less than 25 mm × 25 mm. Maximum depth such that wall thickness is not reduced below minimum.	Accept	Accept	Accept	Accept

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Deformation	Long-term change in dimensions, i.e. creep	Operating at higher temperature than design Operating at higher pressure than design	Weepage failure	Visual inspection	None	Leakage not acceptable	N/A	N/A	N/A	Accept, but monitoring required
Delamination (internal)	"Bright solid" area in laminate due to lack of bond between resin and fibres. Separation of layers (plies) within laminate	Poor quality manufacture Impact damage	Weepage failure	Visual inspection	Ultrasonics Radiography	None permitted	Reject	Reject	Reject	Accept, minor repair but monitoring required. Major repair if service other than sea or potable water
Dimensional changes	Changes in dimensions	Resulting from loads, deflections imposed on the system	Weepage failure	Visual inspection	None	None permitted	N/A	N/A	N/A	Accept if no leakage, but monitoring required.
Dry spot	Area of incomplete surface film where the reinforcement has not been wetted by resin, leaving bare exposed fibres	Poor quality manufacture	Minor effect on performance	Visual inspection	None	None permitted	Reject	N/A	Reject/major repair	Major repair
Erosion	Loss of wall thickness	Particulates in flow	Reduction in wall thickness leading to pipe weepage	Ultrasonics	Ultrasonic B-Scan, Ultrasonic time of flight (TOF), radiography, acousto-ultrasonics	None permitted	N/A	N/A	N/A	Major repair (also flow conditions should be altered to remove particulates from flow)
Flange cracks	Light area with or without broken fibres	Bolts over or under torqued. GRP against raised-face flanges. Wrong GRP flange design selected.	Joint not sealed, leakage Reduced life	Visual inspection	Ultrasonics or radiography	None permitted	Reject	Reject	Reject/ major repair	Detected during operation: Grind crack to maximum depth of less than 30 % of flange step, and perform minor repair

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
										Crack deeper than 30 %, or detected during manufacture or pre-fabrication or installation: No cracks permitted. Reject/ major repair
Fracture	Rupture of laminate with complete penetration. Majority of fibres broken. Visible as lighter coloured area of interlaminar separation	Design conditions, loads, temperatures exceeded. Operational procedures inadequate (e.g. water hammer due to valve opening).	System failure	Visual inspection	Acoustic emission	None permitted	Reject	Reject	Major repair	Major repair
Low energy impact damage	Light area with or without broken fibres	Incorrect transport Incorrect handling	Weepage or pipe failure for low energy impacts For high energy impacts as above but burst is also possible	Visual inspection, with light source inside pipe	Transient thermography, ultrasonics, microwave, shearography, acousto-ultrasonics	Circular or ellipsoidal "bright solid" areas (diameter greater than 25 mm), none permitted No leak at design pressure or at normal operating pressure	Reject	Reject	Major repair	Accept/ minor repair if service is sea or potable water, but monitoring required.
						Ring areas of diameter less than 25 mm No leak at design pressure or at normal operating pressure	Major repair	Major repair	Major repair	Accept/ minor repair Major repair if service other than sea or potable water
						Leak at design pressure or at normal operating pressure	N/A	N/A	Major repair	Major repair

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Inadequate bond (e.g. "kissing" or "tight crack")	Touching faces, no adhesive	Poor quality joint assembly	Weepage failure at joint	Radiography	Ultrasonics	Debond area greater than 30 % of total bond area Axial length of debond greater than 20 % of total axial bond length	Reject	N/A	Reject	Major repair
Inadequate cure of lamination resin or adhesive	Outside temperature and humidity specification Incorrect bonding/cure procedure	Incorrect formulation Out-of-date components Incorrect curing cycle Excessive ambient humidity Outside temperature and humidity specifications Improper mixing Heating pad overlap or controller problems Cooling effect of air in pipe Out-of-date or incorrect materials	Weakened joint or leakage	In accordance with ISO 14692-2:2017, 7.2.4	Differential Scanning Calorimetry (DSC) to determine T_g for adhesive and degree of cure.	In accordance with ISO 14692-2:2017, 7.2.4	N/A	N/A	Remake joint (major repair) Post-cure joint (minor repair)	N/A
Inclusion	Foreign matter wound into laminate	Poor quality manufacture	Reduced pressure to cause weepage	Visual inspection	Ultrasonics Radiography	None permitted	Reject	N/A	Reject	N/A

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Incorrect lamination	Laminated joint incorrectly laid up with missing plies	QA procedures not followed Incorrect raw materials used	Weepage Joint or pipe failure if strength not adequate	Visual inspection, with light source inside pipe if appropriate, followed by radiography as agreed by the principal and manufacturer	Ultrasonics	None permitted	Reject	N/A	Reject	N/A
Incorrect spool dimensions	Incorrect dimensions, misaligned components	Incorrect spool design Incorrect manufacture Incorrect prefabrication. Joint not shaved correctly.	Joint cannot be sealed, leakage GRP can be overstressed if joint pulled up	Measurement to verify documented dimensions	Ultrasonic wall thickness measurement	If misalignment can be compensated elsewhere in the system	N/A	N/A	Accept	N/A
						If misalignment results in overstress caused by joints being pulled up	N/A	N/A	Reject	N/A
Lack of adhesive	Unbonded area of joint face	Too little adhesive or not applied uniformly Movement during curing	Weakened joint or leakage	Radiography or ultrasonics	Microwave inspection, shearography, acousto-ultrasonics or tap testing	Debond area greater than 30 % of total bond area Axial length of the debond area greater than 20 % of total axial bond length	Reject	N/A	Reject	N/A
Lack of fibres	Resin/fibre ratio too high	Poor quality manufacture	Weepage failure	Visual inspection	Radiography	None permitted	Reject	N/A	Reject	N/A
Material degradation	Breakdown of resin, brittleness, softness/swelling due to ageing, chemical exposure, moisture ingress, etc.	Long-term materials degradation	Weepage	Ultrasonics	Destructive testing and characterisation of condition Ultrasonics, microwave, shearography, acousto-ultrasonics or transient thermography NDE using ultrasonic velocity to measure matrix cracking non-destructively	Leakage not acceptable	N/A	N/A	N/A	Accept if no leakage, but monitoring required

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Misaligned joints	Movement during curing and air sucked in, resulting in voids Joint not shaved correctly Inadequate bond area Incorrect dimensions	Movement during curing. Bending Incorrect dimensions	Air sucked in, resulting in voids Residual stress, resulting in less than rated performance	Visual inspection or radiography	Ultrasonics	None permitted	N/A	N/A	Reject or major repair	N/A
Pit (pinhole)	Small crater in the inner surface of the laminate, with width (maximum diameter) similar to or smaller than depth	Poor quality manufacture	Weepage failure for large pits	Visual inspection	Radiography	Diameter greater than 12,5 mm and/or depth greater than liner thickness or 10 % of wall thickness, and/or damaged fibres	Reject	Reject	Reject	Reject
						Diameter greater than 3 mm and smaller then 12,5 mm and/or depth greater than half the liner thickness	Minor repair.	Minor repair	Minor repair	Minor repair
						Diameter less than 3 mm, and depth less than half the liner thickness, and no damaged fibres	Accept	Accept	Accept	Accept
Restriction (excess adhesive)	Excessive resin, adhesive, foreign matter on the internal wall of pipe/fitting causing restriction Scale deposits	Too much adhesive applied Operating conditions resulting in deposits forming inside of pipe	Restriction in pipe to flow Increased risk of erosion damage of pipe	Radiography	Internal visual inspection with endoscope	Flow obstruction of 5 % of inner diameter or 10 mm height, whichever is smaller	Remove by careful grinding	Remove by careful grinding	If access: Remove by careful grinding If no access: Reject/ major repair	If access: Remove by careful grinding If no access: Reject/ major repair

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Uneven wall thickness or contamination after grinding of adhesive joint surface	Uneven wall thickness or contamination after grinding of adhesive joint surface	Contaminated surface after grinding	Weakened joint or leakage	Visual inspection	None	Allowable eccentricity: 0,002 × ID > 0,3 mm	Major repair	N/A	Major repair	N/A
Wear scratch	Shallow mark caused by improper handling, storage and/or transportation. If reinforcement fibres are broken, then damage is considered a crack	Incorrect transport. Incorrect handling	Weepage or pipe failure for low energy impacts. For high energy impacts as above but burst is also possible	Visual inspection, with light source inside pipe	Transient thermography, ultrasonics, microwave, shearography, acousto-ultrasonics	Undamaged fibres are exposed over any area, or no fibres are exposed but an area equal to or greater than 25 mm × 25 mm lacks resin	Minor repair	Minor repair	Minor repair	Minor repair
						No fibres are exposed and area lacking resin is less than 25 mm × 25 mm	Minor repair	Minor repair	Minor repair	Accept
Weeping	Liquid penetration through pipe wall or joint	Over pressure of pipe system	Weepage	Visual inspection Ultrasonics	Radiography	None permitted	Reject	N/A	Reject	Major repair
Weld sparks	Minor breakdown of outer surface due to effects of close-proximity welding	External sparks of nearby welding procedures	Minor effect on performance	Visual inspection	None	Same as for "Wear scratch"	Minor repair	Minor repair	Minor repair	Accept

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Table A.1 *(continued)*

Defect type	Description	Cause(s)	Consequence(s)	Recommended NDT method(s)	Other potential NDE methods	Criteria	Corrective action	Corrective action	Corrective action	Corrective action
							Manufacture	Delivery	Installation	Operation
Threaded joints										
Tears, cuts, grinds, shoulders, or any other imperfections	Continuity of the threads is broken	Teeth damaged	Joint cannot be sealed, leakage	Visual inspection	Radiography or leak testing	None within minimum length of full crest threads (L_c) from end of pipe	Reject	Reject	Reject	N/A
Air bubbles	Small bubbles at crest of threads	Minor damage to teeth	Minor reduction in joint sealing performance	Visual inspection	None	Maximum length 5 mm, one per thread Maximum length 2 mm, ten per thread	Accept	Accept	Accept	N/A
Chips	Areas where over 10 % of thread height is removed	Teeth chipped	Joint cannot be sealed, leakage	Visual inspection	Radiography or leak testing	Max. 10 mm long, one permitted per thread outside the L_c area.	Accept	Accept	Accept	N/A
						None permitted in the L_c area	Reject	Reject	Reject	
Cracks	In axial pipe direction	Stength of joint reduced	Weepage failure	Visual inspection	Radiography	None permitted	Reject	Reject	Reject	N/A
	In radial pipe direction	Stength of joint reduced	Weepage failure	Visual inspection	Radiography	None permitted that extend from teeth root into first ply of pipe wall	Reject	Reject	Reject	N/A
Flat thread	Area where top of thread is broken or ground off	Teeth damaged	Joint cannot be sealed, leakage	Visual inspection	Radiography or leak testing	Max. 10 mm long, one permitted per thread outside the L_c area, not to exceed 10 % of thread height.	Accept	Accept	Accept	N/A
						None permitted in the L_c area	Reject	Reject	Reject	N/A
Finish	Finish cut end	Damaged end faces	Joint cannot be sealed, leakage	Visual inspection	Radiography or leak testing	Sharp edges, exposed fibres, protrusions and/or impact areas are not permitted	Reject	Reject	Reject	N/A

NOTE N/A = not applicable; L_c is the length measured from the end of the pipe to the furthest full crest thread.

Annex B
(normative)

Handling and storage

B.1 Handling

B.1.1 General

GRP piping components can be susceptible to mechanical damage from impact, sharp edges or scratching. Special consideration should therefore be given to protecting components and to ensure that all personnel involved are given training in the relevant procedures. End protection of piping components shall remain in place during handling and transport.

Manufacturers shall supply detailed handling and storage requirements for pipes, fitting, adhesives and ancilleries.

B.1.2 Lifting and transportation

Lifting, loading, unloading and transportation shall be performed in accordance with procedures agreed between the principal and the manufacturer. Under no circumstances shall pipe, fittings or pipe spools be thrown or dropped from any height. Furthermore, no chains, wire ropes or clamps shall be used for lifting pipes, fittings or pipe spools.

Pipe of small diameter can easily be lifted by hand. Short pipe sections, up to 3 m in length, may be lifted with a crane using at least one sling made of 100 mm wide canvas or suitable plastic. Longer pipe sections, up to 6 m in length, may be lifted with a 3 m spreader bar and two slings of 100 mm wide suitable plastic. The lifting point or points shall be such that the pipes are well balanced. Pipes shall be transported, either packed in a container or strapped onto pallets. See B.2 for packing/storage requirements.

Fittings shall be loaded by hand onto pallets, or into crates or baskets, with intercomponent packing material to avoid transportation damage, and shall be strapped down during lifting.

For lifting pipe spools, two or more slings of 100 mm wide suitable plastic may be necessary. The lifting points shall be such that the pipe spools are well-balanced. The canvas or suitable plastic slings shall not be placed under fittings or pipe connections.

During transportation, all components shall be firmly secured to prevent excessive movement.

B.1.3 Temporary supports

Temporary restraining supports shall be attached to complex prefabricated spools prior to lifting, in order to minimize bending strain in the spools.

B.2 Storage

B.2.1 General

Storage of piping components may be required prior to installation. Consideration shall be given to the state of the storage surface (i.e. level, with no sharp objects), high winds and temperature.

B.2.2 Pipe

Pipe may be stacked for space-saving storage as illustrated in Figure B.1, subject to the following requirements.

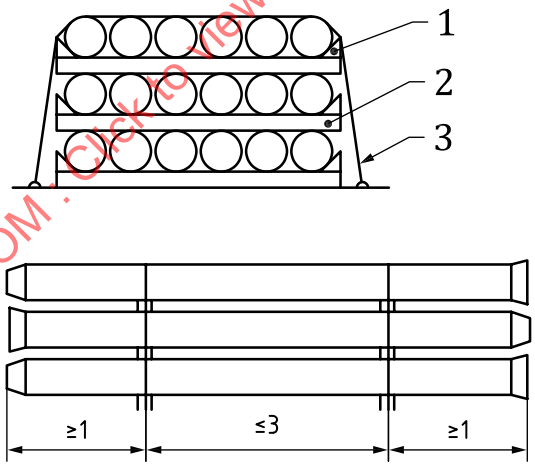
a) Pipe may be stacked in heights up to 2,5 m if side supports are provided. Spacer stripping (approximately 50 mm × 100 mm) should be used both as supports for the pipes and as separators between pipe layers. The plastic or wooden stripping when in pipe stacks should be located directly above each other. Spacer stripping thickness should be sufficient to ensure that pipes are not in contact with each other. The maximum distance between supports shall be 3 m and the supports shall be placed at a minimum of 1 m from the end of the pipes. Pipe with bell ends may be stored with the bell ends in alternate directions to avoid contact and possible damage to the ends. Alternatively, pipes with bell ends may be stored with the bell ends in the same direction but with the ends of the pipes axially displaced to ensure that the ends are not in contact with each other. Spacer stripping shall be located clear of the bell ends.

b) Pipes of small diameter may be stored inside pipes of larger diameter, assuming that spacers are used and that the spacers are of sufficient size (at least 25 mm) and strength (at least that of GRP) to prevent contact between the pipes. Spacer gap size shall be no greater than 3 m.

c) End protection should protect both inside and outside of the pipe ends and shall remain in place during storage. Thickness of wooden stripping shall be sufficient to ensure that pipes are not in contact with each other.

d) Strapping down of GRP pipe stacks may be necessary to prevent damage during high winds. Suitable tie-downs such as nylon straps or padded metal strapping should be used to secure the stack. Caution should be used to prevent damage when securing the stack.

Dimensions in metres



Key

1 side support
2 spacer support
3 strapping rope

Figure B.1 — Stacking of pipes

B.2.3 Fittings

Fittings may be shipped in crates or boxes and may be stored in these crates or boxes, provided the package is undamaged and suitable for long-term storage. End protection of fittings and flanges should remain in place during storage.

B.2.4 Pipe spools

Pipe spools should be packed by the manufacturer to avoid damage during transportation. If possible, the pipe spools shall be stored with this temporary protection in place. End protection of fittings and flanges should remain in place during storage. Pipe spools shall not be stacked.

B.2.5 Adhesive/resin systems

Adhesive kits and resin systems shall be stored in the original packaging in accordance with the pipe manufacturer's recommendations and safety regulations applicable to the storage location.

All separately delivered fire-protection materials shall be delivered at the receiving facility in factory-sealed containers or in crates. Storage conditions shall be in accordance with the material safety data sheet for the material in question.

Particular attention shall be accorded to the recommended storage temperatures and humidity, and the requirement to keep certain materials apart for fire safety reasons. Unless otherwise specified by the manufacturer, materials shall be stored in the original packaging at a temperature of between 10 °C and 30 °C.

If the shelf life of any component of the adhesive kit or resin system is exceeded, then the component or resin shall be disposed of in the appropriate manner (as defined by the manufacturer).

B.2.6 Ancillaries

Ancillary materials (elastomeric O-rings, flange gaskets, locking strips, reinforcements and lubricants) shall be stored in accordance with the manufacturer's recommendations.

Annex C
(normative)

Minimum training requirements for bonder, pipe fitter, spool builder, supervisor and inspector

C.1 General

Installation and joining of GRP pipes differ considerably from the techniques used for the installation of steel pipes, but for both types of pipe, the quality of the installation work depends on satisfactory craftsmanship. Training and assessment of personnel is accordingly an important element in the quality assurance and cost-effective use of GRP pipes. This annex specifies the minimum requirements for training and qualification of bonders, pipe fitters, spool builders, supervisors and inspectors for the prefabrication and installation of GRP pipes. Reference [6] provides further details on recommended training requirements.

C.2 Training and assessment organizations

C.2.1 General

The assessment scheme regarding the GRP bonders, spool builders and pipe fitters shall be operated by an independent organization, where it is recommended that this organization works in full compliance with ISO/IEC 17024. The assessment organization shall be acceptable to the principal.

Joint instructions are manufacturer-specific. The training is therefore usually provided by the manufacturer. Candidates shall therefore be trained and assessed on compliance with manufacturers' (joint) instructions. A successful hydro-static test is as such not sufficient exam evidence.

Exams are "spot-checks"; they typically cannot assess all know-how needed. The assessment scheme should therefore set a constant and controllable training level applied by the various participating manufacturers, in order to facilitate a constant and controllable assessment level.

Assessors shall be technical-competent on the know-how related to GRP piping installation and be well informed on the contents of specific manufacturers' (joint) instructions. By preference, the assessment scheme should make use of local and independent professionals complying with these requirements, thus promoting the aimed constant level of assessment. This assessment scheme allows the responsibilities of both trainer and assessor to be taken by one professional, usually employed by the manufacturer, while ensuring that the correct execution of these responsibilities is approved by the external verifier employed by an independent assessment organization.

A flowchart showing the procedure-related functions is presented in Figure C.1. The relationship between the various organizations and manufacturer is presented in Figure C.2.

In summary the roles involved in the training and assessment are:

— Trainee: person undergoing the training and assessment;

— Trainer: person supervising the training (usually employed by the GRP manufacturer);

— Assessor: person overseeing the training and performing the assessment (usually employed by the GRP manufacturer). This person can be the same person as the trainer;

— Internal verifier: person who audits the assessment for compliance with the procedure outlines in this document (usually employed by the GRP manufacturer);

— External verifier: independent person from the trainer, assessor and internal verifier whose role is to verify and approve/revoke the assessment of the trainee. Person is employed by the assessment organization, which is independent to the GRP manufacturer, where this organization is in compliance with ISO 17024;

— Competence committee: a group of specialists who define the requirements of the assessment. Each specialist is appointed by the external verifier;

— Training committee: a group of specialists who define the training requirements. Each specialist is appointed by the external verifier.

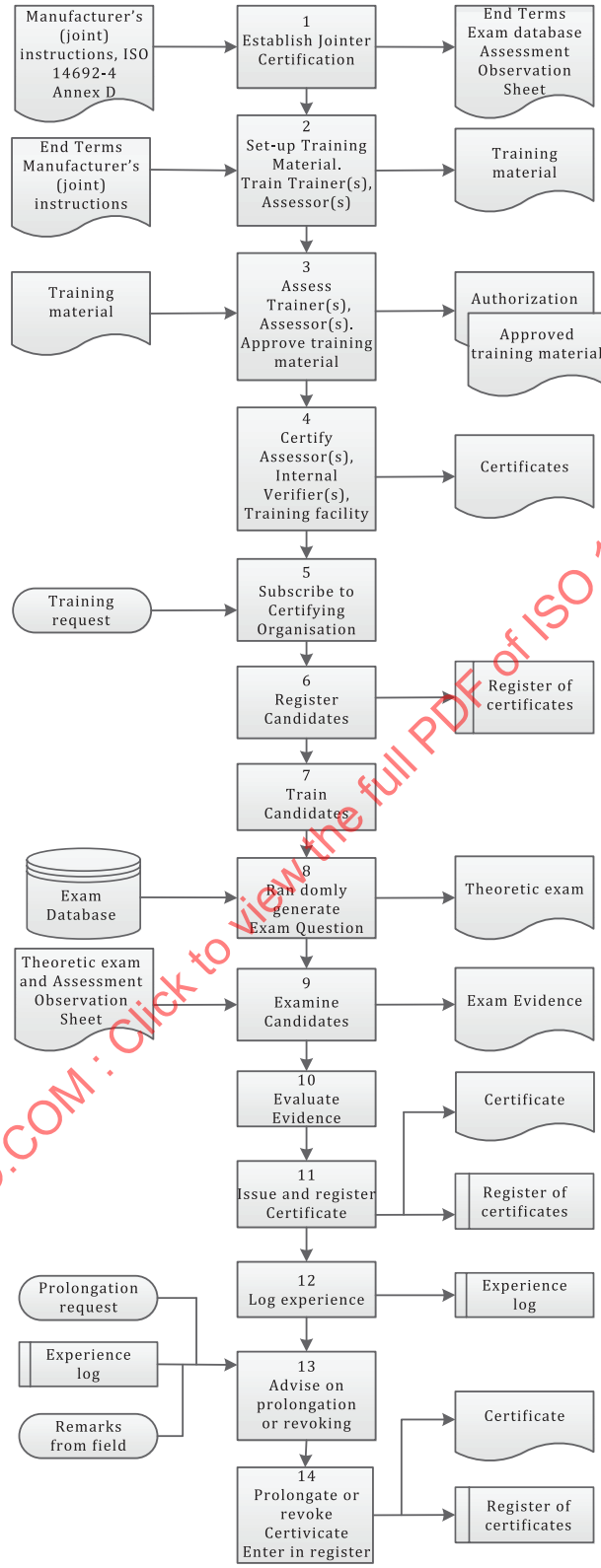


Figure C.1 — Flowchart of the certification scheme

No.	Responsible	Explanation
1	Competence committee	Establish all items needed for the certification. As a minimum: — the exam question database (EQD); — the assessment observation sheet (AOS); — the appointment of the training committee.
2	Training committee	Set up all needed training material for candidates: — as defined in this annex; — manufacturers' (joint) instruction(s).
3	Competence committee	Assess (on technical issues): — trainers; — assessor. Approve training material
4	External verifier	Assess (on procedural issues) and certify: — assessor(s); — internal verifier. Assess and certify: — training facility(ies).
5	Internal verifier	Receive training request and inform assessment organization.
6	External verifier	Register the candidates.
7	Trainer	Train the candidates using the training material.
8	External verifier	Randomly generate exam questions per exam, from the exam question database.
9	Assessor	Examine the trained candidates by: — theoretical exam; — practical exam; — hydrostatic jointers test; — conductivity test (optional). Submit exam evidence to internal verifier.
10	Internal verifier	Audit assessor. Evaluate the exam evidence. Propose the candidate for successful assessment if all aspects are in conformance with this annex. Archive all exam evidence.
11	Assessment organization	Decide on assessment. Where applicable issue the certificate to candidate and enter him (her) in the register as a successfully assessed professional. Archive exam evidence.
12	Successfully assessed professional	Log experience on jointing, spoolbuilding and/or pipe fitting as appropriate to the certificate, and make sure this is authenticated.
13	Internal verifier	Investigate the authenticated experience log as well as remarks made. Check for compliance with this annex. Advice on prolongation or revoking.
14	External verifier	Decide on prolongation or revoking of certificate. Where applicable issue the certificate prolongation or revoke the certificate. Enter the prolongation or withdrawal of the certificate in the register.

C.2.2 Flowchart clarification

C.2.2.1 General

This subclause provides clarification of the various steps in the assessment scheme.

C.2.2.2 Item no. 1 — Clarification

The competence committee (CC) shall generate, and is responsible for the following actions.

a) The approval of the exam question database (EQD) (see Table C.3).

b) The approval of the assessment observation sheet (AOS) (see Table C.3). The AOS documents the exam results; an example is shown in Table C.11.

c) The approval of the training committee.

The access to the EQD is restricted to the external verifier. Neither the trainer nor the assessor shall be informed about the contents of the EQD.

C.2.2.3 Item no. 2 — Set-up training material. Train trainer(s) and assessor(s)

The training committee shall generate and maintain the theoretical and practical training for candidates, as well as related training material. The training shall consist of a theoretical and a practical part. It shall comply with:

a) this annex, including the end terms (see Table C.11);

b) relevant manufacturers' instructions, such as HSE instruction(s), joint assembly instruction(s), adhesive instruction(s), installation guide(s), material safety data sheet(s), etc.

The diameter of joints made during practical training should be slightly different from the diameters used during practical exam.

The external verifier shall approve the appointment of the trainer(s) and/or assessor(s).

The training and competence of the trainer and assessor shall comply with C.2.4.

C.2.2.4 Item no.3 — Assess trainer(s) and assessor(s)

The CC shall assess (on technical issues) the trainer(s) and/or assessor(s).

The assessment shall comply with C.2.4.

The CC shall approve the training material.

C.2.2.5 Item no. 4 — Verify trainer(s)/assessor(s), internal verifier(s) and training facility(ies)

The external verifier shall assess (on procedural issues) and provide assessment for:

a) trainer(s) and/or assessor(s);

b) internal verifier(s).

The training and assessment shall comply with C.2.4.

The external verifier shall provide assessment and verification of training and exam facilities (see C.2.4).

The certificate of trainer(s)/assessor(s), as well as the internal verifier, shall be valid for a period of 2 years from the date of successful completion of the examination. The external verifier shall decide on the prolongation or revoking of certificate based on experience of the certificate holder. The certificate shall show the information stated in C.2.4.

C.2.2.6 Item no. 5 — Subscribe to external verifier

The training/assessment request shall specify required profession(s) (per Table C.1 and Table C.2) and joint types (per Table C.4) for each candidate. The request shall be addressed to the internal verifier.

He/she subscribes the candidate(s) to the external verifier, at least 1 week prior to the start of the training.

C.2.2.7 Item no. 6 — Registration of candidates

The external verifier registers the candidate(s).

C.2.2.8 Item no. 7 — Train the candidates using the training material

The trainer trains the candidate(s) in accordance with a) the request (see C.2.2.6) and b) the theoretical and practical training as generated by the training committee. The trainer judges the candidate(s) on their capability to enter the exam. If not found capable, the candidate shall be re-trained or be advised to withdraw from the assessment process.

C.2.2.9 Item no. 8 — Randomly generated exam questions

The external verifier generates the questions for the theoretical exam in accordance with the request (see C.2.2.6), by random selection from the EQD. The number of questions per subject and profession type shall comply with Table C.6. Neither the trainer nor the assessor shall be informed on the randomly generated exam questions. The exam questions shall be handed over to the assessor in a closed and sealed envelope (or equivalent).

C.2.2.10 Item no. 9 — Randomly generated exam questions

The assessor assesses the trained candidates. The exam shall comply with the request (see C.2.2.6) and consists of the following elements.

a) The theoretical exam consisting of a maximum of two-hour open-book exam, using the randomly generated exam questions (see C.2.2.9).

b) The practical open book exam consisting of the independent jointing of a representative joint by each candidate. The candidate shall comply with:

   1) actions and requirements described in the end terms, using representative products, all as specified in Table C.11 and as applicable to the request (see C.2.2.6);

   2) the manufacturers' (joint) instructions;

   3) the dimensional requirements described in Table 1 and Table 2.

c) The hydrotest, in which the representative joint(s) made by the candidate shall pass the hydrotest as specified in Table C.9.

d) Where applicable, the conductivity test, in which the representative joint(s) made by the candidate shall pass the conductivity test as specified in Table C.10.

The assessor shall secure authentic and independent work of candidates, during both theoretical and practical exam. As a minimum, the following applies.

— The candidate shall not be assisted by the assessor and internal verifier, neither verbally nor physically.

— Authentic and independent work shall be secured by lay-out of the examination area(s) and supervision of the assessor. In order to maintain overview during the practical exam, the number of candidates assessed simultaneously by one assessor should be limited to 6;

— The sealed envelope containing the exam questions (see C.2.2.9) shall only be opened at the start of the theoretical exam. Direct upon conclusion of the theoretical exam, the assessor shall put the questions and answers again in a sealed envelope.

— During the practical exam, the candidate may be assisted by (a) helper(s), e.g. to assist in handling. In that case, the candidate remains responsible for the work done by the helper(s). The helper shall not remind the candidate on the items stated in the end terms, including contents of manufacturers' (joint) instruction(s).

The assessor shall collect the following exam evidence for each candidate.

a) Theoretical exam.

The assessor shall sign the AOS when candidate answers meet the requirement per Table C.6. The answers shall be attached to the AOS in a sealed envelope.

b) Practical exam.

The candidate shall

— list the required information on the AOS, and

— sign for compliance with manufacturers' (joint) instructions at each hold point.

The assessor shall approve the AOS per hold point when the candidate has met the requirements per Table C.7. The candidate shall only continue the work after approval of the hold point by the assessor.

Attitude

The assessor shall evaluate the candidate's attitude based on a) use of PPE, b) behaviour, c) ability, d) use of checklist, and report his/her findings on the AOS.

Recorded questions and answers

During the practical exam, the assessor shall ask each candidate at least two non-leading questions related to the manufacturers' (joint) instruction(s). Both questions and answers shall be recorded or written on the AOS.

Video recording

The practical exam shall be recorded by at least one static video camera, adequately overviewing the total exam area and showing candidate(s), as well as assessor(s), during the entire practical exam.

Photos

In case of deviation by candidate from the manufacturers' (joint) instruction(s), the assessor shall take photos showing the deviation and the candidate.

Hydrotest

The assessor shall sign the AOS when the test result(s) meet(s) the requirement(s) per Table C.9. The test report shall be attached to the AOS.

Conductivity test (optional)

The assessor shall sign the AOS when the test result(s) meet(s) the requirement(s) per Table C.10. The test report shall be attached to the AOS.

The assessor shall submit the exam evidence, including the AOS, to the internal verifier.

C.2.2.11 Item no. 10 — Evaluation of exam evidence

The internal verifier audits the assessor on compliance with this annex.

The internal verifier evaluates the exam evidence and approves it when in conformance with:

a) this annex, including the end terms (see Table C.11);

b) the manufacturers' (joint) instructions.

The internal verifier submits the approved exam evidence to the external verifier.

C.2.2.12 Item no. 11 — Registration and issue of certificate

The assessment organization decides on issuing a certificate of proficiency to the candidate based on:

a) the approved exam evidence;

b) audits by external and internal verifier as described in this annex.

When issued, the assessment organization shall:

— register the certificate; and

— issue the certificate to the candidate at a maximum of 2 working days after submittal of exam evidence by the internal verifier.

When not issued, the assessment organization shall:

a) remove the candidate from registration file (see C.2.2.7); and

b) inform the candidate and the internal verifier accordingly, at a maximum of 2 working days after submittal of exam evidence by the external verifier.

The certificate shall be valid for a period of 2 years from the date of successful completion of the examination. The certificate shall show the information stated in Table C.5.

All steps leading to successful assessment (i.e. theoretical training and exam, practical training and exam, tests) can be carried out separately over an extended period of time but they shall have been completed within 2 months for the candidate to achieve successful assessment. However, it is recommended that all steps be carried out consecutively over a short period of time.

C.2.2.13 Item no. 12 — Log experience

The successfully assessed professional shall log authenticated evidence relevant to jointing work carried out, including information on the type and number of joints prepared. See Table C.3.

C.2.2.14 Item no. 13 — Advise on prolongation/revoking

Requests for prolongation or revoking of the certificates shall be addressed to the internal verifier. He/she subscribes the requests to the assessment organization.

The assessment organization registers the request. The external verifier

a) reviews the request, as well as the experience log for compliance with this annex,

b) advises on requested training and assessment, and

c) informs the assessment organization of the findings.

C.2.2.15 Item no. 14 — Issue certificate prolongation or revoking

The external verifier decides on issuing a prolongation of the certificate or decides to revoke the certificate based on the following:

a) the findings provided by the internal verifier (see C.2.2.14);

b) audits by external and internal verifier as described in this annex.

When prolonged, the assessment organization shall

— register the certificate prolongation, and

— issue the prolongation of the certificate to the candidate at a maximum of 2 working days after submittal of advice and (where applicable) exam evidence by the internal verifier.

When revoked, the assessment organization shall

a) register the certificate as such, and

b) inform the candidate and the internal verifier accordingly, at a maximum of 2 working days after submittal of advice by the external verifier.

The prolongation of the certificate shall be valid for a period of 2 years from the date of prolongation.

C.2.3 Basic skills, age and experience

The candidate shall understand the language in which the course is being conducted. The candidates shall be in satisfactory physical condition and shall have eyesight which fulfils either of the following requirements (as assessed by an optician):

— ISO 9712 or equivalent and have an eyesight test every 12 months; or

— unaided or corrected near visual acuity in at least one eye, such that the candidate is capable of reading N4 Times Roman type at a distance of not less than 30 cm on a standard reading test.

In order to be admitted to the training and the exam, the candidate shall be aged 18 years at the minimum and shall fulfil the following minimum experience requirements:

a) pipe jointer: capable to execute joint instruction(s), to be demonstrated by this assessment process;

b) spoolbuilder: same as pipe jointer and, in addition, fulfil one of the following minimum requirements:

   1) have a trade certificate demonstrating basic skills related to independently read isometric drawings and apply/control the dimensions shown to form a pipe spool;

   2) have a minimum of 1 year documented spoolbuilder experience.

Only the required specific GRP knowledge will form part of the training and the exam:

c) pipe fitter: Same as pipe jointer and, in addition, fulfil either of the following minimum requirements:

   1) have a trade certificate demonstrating basic skills as an industrial pipe fitter, able to independently install piping;

   2) have a minimum of 1 year documented pipe fitter experience.

Only the required specific GRP knowledge will form part of the training and the exam.

Other documented evidence of education, training and experience may be considered to give equivalent competence.

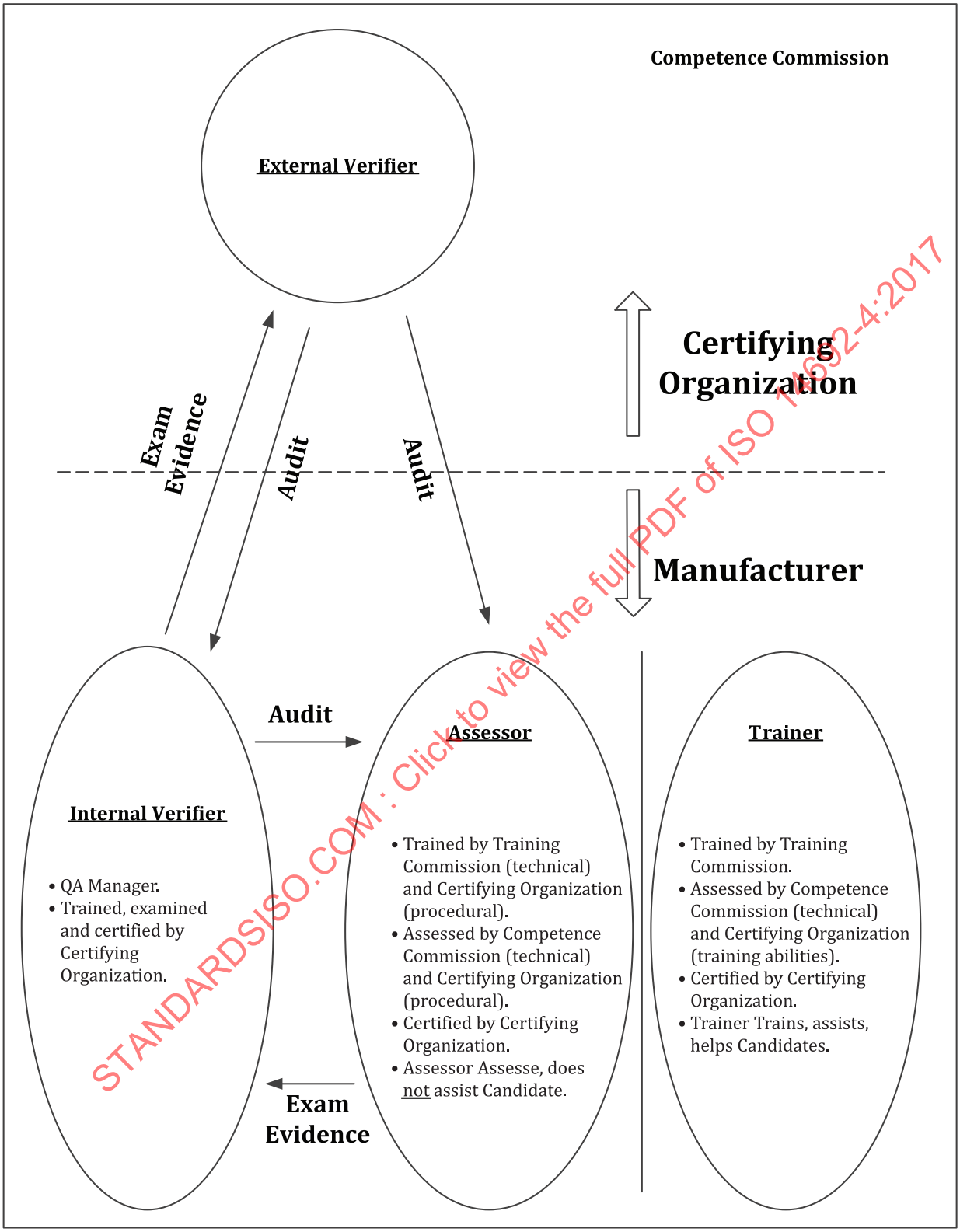


Figure C.2 — Procedure-related functions diagram

Table C.1 — Profession-related definitions and responsibilities

Profession	Definition	Responsibility
Pipe jointer	An individual who joins GRP pipe(s) and fittings(s) (straight joints only[a]).	— Work according to relevant jointing procedures — Work according to relevant procedures related to handling, storage, health and safety — Work according to relevant repair procedures — Registration of relevant information
Spoolbuilder-A	An individual who joins GRP pipe(s) and fittings(s) (straight joints only) according to dimensions shown on isometric(s).	Same as pipe jointer and, in addition: — Work according to dimensions shown on isometric(s) — Work according to relevant jointing procedures addressing accuracy of dimensions per 4.5.7.1 — Work according to mill hydrotest procedures — Registration of relevant information
Spoolbuilder-B	An individual who fabricates GRP pipe spools from segmented pipes and fitting laminates according to dimensions shown on isometric(s).	Same as spoolbuilder-A and, in addition: — Work according to relevant procedures for fabrication of laminated fittings, addressing accuracy of dimensions per Figure 1
Pipe fitter	An individual who installs GRP piping	Same as pipe jointer and, in addition: — Work according to relevant procedures for installation of GRP piping — Work according to piping isometric(s) — Work according to field hydrotest procedures — Registration of relevant information
Supervisor[b]	An individual able to perform practical supervision of the installation and joining of composite pipes.	— Responsible for, and coordinate/monitor, the work done by pipe jointer, spoolbuilder-A and -B and/or pipe fitter. The supervisor reports to (and usually is an employee of) the installer.
Inspector[b]	An individual able to perform independent inspection.	— Independent inspection of GRP pipe installations and installation work, on compliance with the purchase order. The inspector reports to the principal.

[a] Straight joint: joint where centre lines of jointed parts (e.g. bell/spigot or plain/plain) are in line.

[b] To date, no end terms have been defined for this profession, hence, no assessment can be provided.

Table C.2 — Procedure-related definitions and responsibilities

Entity	Definition	Responsibility
Principal	Party that initiates the project and ultimately pays for its design and construction	— The principal generally specifies the technical requirements and is ultimately responsible for ensuring that safety and all other issues are addressed. The principal may also include an agent or consultant, authorized to act for the principal.
Assessment organization	A recognized organization acceptable to the principal	— Independent issuing and registration of certificates for professions stated in Table C.1 — Adequate level of workmanship covered by these certificates — Participate in competence commission — Certify trainer(s)/assessor(s), internal verifier(s) and training facilities — Provide external verifier(s)
Consultant	Party which carries out all or part of the design and engineering for a project	— Independent execution of all or part of the design and engineering of a project — Could be appointed by the principal to act on their behalf — Participate in competence commission, acting on behalf of the principal
Manufacturer	Party which manufactures or supplies GRP pipe components	— Usually provides trainer and training of pipe jointer, spoolbuilder-A and -B and pipe fitter. — Usually provides assessor and internal verifier for examination of these professions — Participate in competence commission
Competence committee	An appointed group of specialists, acceptable to the principal, that defines and guards the assessment process. Members (minimum): — assessment organization(s) — consultant(s) — manufacturer(s)	— Provide an open platform that defines and guards the assessment process as an industry standard — Set exam at adequate level — Define and maintain the exam question databank (EQD) and the assessment observation sheet (AOS) — Appoint training committee — Approve training for candidates — Examine and authorize trainer(s) and assessor(s) on technical issues — Decide on disagreements between entities involved with this assessment scheme — Provide feedback on remarks from field
Training committee	An appointed group of specialists that defines and guards the training and related materials	— Defines and maintains the training and training material — Provide adequate technical training and exam for trainers and assessors — Guards standardization of trainings
Candidate	An individual who applies for assessment of profession(s) described in Table C.1	— Comply with minimum entry requirements

[a] Training on specific GRP know-how only.

[b] In order to adequately assess on correct execution of (manufacturer specific) joint instructions, the assessor shall at least be technically trained and examined to the level of trainer.

[c] The QA manager may delegate the function of internal verifier to an appointed QA function.

Table C.2 *(continued)*

Entity	Definition	Responsibility
Trainer	An appointed individual who trains candidates[a]	— Train the candidate(s) — Provide feedback to training committee
Assessor	An appointed individual who assesses the compliance of the candidate with theoretical and practical exam requirements[b]	— Supervise candidates during theoretical exam — Assess candidates during practical exam — Collect exam evidence — Comply with exam requirements for trainer — Act in accordance with a) this annex, as well as b) rules forming part of the assessment — Provide feedback to competence commission
Internal verifier	An appointed QA manager who audits the Assessor on compliance with this annex[c]	— Audit the assessor on compliance with this annex — Assist the trainer in setting-up of training — Act in accordance with a) this annex and 2) rules forming part of internal verifier assessment (by assessment organization) — Verify the exam evidence — Communicate with external verifier
External verifier	An employee of the assessment organization who audits the internal verifier and assessor	— Audit the internal verifier and assessor on compliance with a) this annex and b) rules forming part of their certification (by assessment organization) — Communicate with internal verifier

[a] Training on specific GRP know-how only.

[b] In order to adequately assess on correct execution of (manufacturer specific) joint instructions, the assessor shall at least be technically trained and examined to the level of trainer.

[c] The QA manager may delegate the function of internal verifier to an appointed QA function.

Table C.3 — Document-related definitions

Document	Definition
Exam question database (EQD)	A database containing a large number of questions related to the know-how to be examined[a]. As a minimum, the EQD shall include questions related to the following: — the manufacturer's instructions, such as HSE instruction(s), joint assembly instruction(s), adhesive instruction(s), installation guide(s), material safety data sheet(s), etc.; — the subjects mentioned in the end terms (see Table C.11). The database shall be grouped in line with Table C.6, in order to facilitate at random selection of exam questions.
Assessment observation sheet (AOS)	A document that facilitates a) the simultaneously assessment of candidates during the practical exam and b) registration of measured data. Typically, the AOS will be grouped, each group ending with a hold point. The hold points allow the assessor to keep track of candidates working simultaneously. An example AOS is given in Table C.11.
Experience log	A document that facilitates the logging of relevant and authenticated work experience of certified professionals. As a minimum, the log contains following information: — certificate number of successfully assessed professional;

[a] Indication: five times the number of questions used during exam.

Table C.3 *(continued)*

Document	Definition
	— the type, number and date(s) of joints made by successfully assessed professional and, where applicable, the project identification; — any relevant information related to the quality of work of the successfully assessed professional; — authentication of stated information.
[a] Indication: five times the number of questions used during exam.	

Table C.4 — Product-related definitions

Item	Definition
Joint type	A particular joint method that serves a particular service and may require specific skills for jointing. Joint types are considered identical on the condition that their joint instructions are identical.
Joint instruction	An instruction describing the field installation procedure of a specific joint type
Repair type	A particular repair method that serves a particular service and may require specific skills
Repair instruction	An instruction describing the field installation procedure of a specific repair type
Tool instruction	An instruction describing the field operation procedure of a specific tool

Table C.5 — Minimum contents of certificate

The certificate shall contain the following information:

— family name, initials and photo of certificate holder;
— date and place of birth;
— place of examination;
— date of assessment and expiry date;
— standard of competence achieved, that is:
  — applicable profession, i.e. pipe jointer, spoolbuilder-A, spoolbuilder-B and/or pipe fitter;
  — applicable joint type(s) as specified in Table 1, and the corresponding joint instruction(s);
  — applicable product range in terms of diameters and nominal pressures;
  — applicable conductive product range (optional);
  — applicable repair type(s);
— the manufacturer of joint(s) and manufacturer's product series identifying materials (e.g. glass-reinforced polyester, vinyl ester, epoxy);
— a reference to this annex;
— the assessment organization's stamp and signature;
— candidate's signature.

Table C.6 — End terms — Theoretical exam

No.	Examination subjects	Number of exam questions per profession			
		Pipe jointer	Spool builder-A	Spool-builder-B	Pipe fitter
T.1	GRP, GRP applications and products				
	— Description of joint types applicable to the certificate — Typical joint design aspects (e.g. tapered and conical/cylindrical adhesive joints, taper angle, bonding length, type of adhesive, type of O-rings, type of gaskets and their limitations/use, etc.) — Description of various (GRP and steel) flange types — Typical applications of GRP, abbreviations used, advantages, disadvantages — Typical manufacturing methods of GRP — Typical tools for GRP jointing, spool building and installation	In total 4	In total 4	In total 4	In total 4
	— Labelling, piping systems, pressure classes, identification codes	1	1	1	1
	— Packing, storage, handling, loading and unloading of GRP products. — Packing, storage, handling of raw materials (e.g. glass reinforcements, adhesives, resins, hardeners, etc.) — Packing, storage, handling of accessories (e.g. O-rings, gaskets, locking keys, etc.) — Packing, storage, handling of tools (e.g. shavers, temperature/humidity/dew-point measuring devices, torque wrenches, etc.	In total 2	In total 2	In total 2	In total 2
	— Sequence of joint instruction process steps.	1	1	1	1
T.2	Joint instructions				
	— Execution of joint instruction(s), including but not limited to (as applicable): — Limitations and corrective actions (e.g. temperature, dew point, use of sheltering) — Dimensioning of joint — Cleaning — Preparation of joint surfaces — Preparation for joint assembly — Joint assembly — Curing	In total 7	In total 7	In total 7	In total 7
	— Use of tools and contents of tool instructions for joint types applicable to the certificate (e.g. field shavers, curing blankets, temperature/humidity/dew-point measuring devices, torque wrenches, etc.).	4	4	4	4
	— Use of exam log(s) of joint types applicable to the certificate.	1	1	1	1
T.3	Health and safety regulations — Hydrotest safety protocols (integrity test versus leak test, awareness of stored energy difference of GRP versus steel, de-airing, safe personnel distance, etc.). — Use of PPE with respect to dust, noise, protection, etc. — Safe use of relevant machinery for cutting, sanding, shaving, pulling, etc. — Safe use of relevant raw materials, MSDS, certificates, remedial actions, etc. — Basic safety rules with respect to GRP related to eating, drinking, personal hygienic — Awareness of project-specific standards and specifications related to safety protocols	1 question each subject (total 6)	1 question each subject (total 6)	1 question each subject (total 6)	1 question each subject (total 6)

Table C.6 *(continued)*

No.	Examination subjects	Number of exam questions per profession			
		Pipe jointer	Spool builder-A	Spool-builder-B	Pipe fitter
T.4	Installation techniques — Contents of manufacturers installation guide, including (but not limited to): — Installation techniques for underground and above ground piping. — Trench construction and –inspection, backfilling, compacting. — Support types and their use. Support inspection. — Installation of bellows. — Awareness of project-specific requirements (e.g. field hydrotest) — Determination of manpower needed	—	—	—	In total 5
T.5	Quality systems and procedures				
	— Inspection of piping components incl. packing (e.g. impact damage, scratches, cracks, de-laminations, etc.) — Inspection of raw materials, adhesive, accessories, tools, including packing (e.g. aged/cracked O-rings, gaskets, etc.) — Conductivity test (where applicable) — Traceability of raw materials (glass reinforcements, adhesives, resins, hardeners, etc.) — Traceability of piping components — Traceability of accessories (O-rings, locking keys, gaskets, etc.) — Registration of jointing, installation, repair — Calibration status of applicable measuring devices (e.g. torque wrench, temperature/humidity/dew-point measuring devices, etc.) — Awareness of project-specific standards and specifications related to the piping installation (e.g. safety procedures, field hydrotest procedures, etc.)	In total 3	In total 3	In total 3	In total 3
	— Recognize correct type of raw materials, adhesive, accessories, tools, etc.	2	2	2	2
	— Control on spool dimensions shown on isometric(s) — Hydrotest procedures for spools	—	3	3	—
	— Compliance with system design and isometrics. (e.g. field hydrotest pressure, inspection of a) routing, b) supporting, c) trench and d) backfill, both prior to field hydrotest and final, etc.) — Control on routing and dimensions of piping, alignment, etc. — Field hydrotest procedures for piping (integrity test, leak test, influence of temperature and elevation, etc.) — Possible causes of leakage (e.g. result of pipe damage, excessive pipe load generated by displacements resulting from incorrect backfill and/or supporting, dirt at O-ring, “slip ring”, incorrect gasket installation, etc.)	—	—	—	In total 3
T.6	Manufacturing of pipe spool				
	— Determination from isometric of amount of pipe, pipe lengths, fittings, amount of adhesive, amount of laminating materials, type and amount of tools — Correct supporting during assembly (e.g. avoiding movements, bending, using non-abrading slaps, etc.)	—	In total 1	In total 1	—

Table C.6 *(continued)*

No.	Examination subjects	Number of exam questions per profession			
		Pipe jointer	Spool builder-A	Spool-builder-B	Pipe fitter
	— Assembling of three-dimensional spool(s) from pipe(s) and fitting(s) in accordance with: a) dimensions shown on isometric; b) tolerances shown in Table 1 and Table 2; c) appropriate joint instruction(s); d) appropriate QC procedure(s)	—	In total 5	—	—
	— Execution of fitting laminate procedure(s), including QC — Assembling of three-dimensional spool(s) from segmented pipes and fitting laminates in accordance with: a) dimensions shown on isometric; b) tolerances shown in Table 1 and Table 2; c) appropriate fitting laminate procedure(s); d) appropriate QC procedure(s)	—	—	In total 5	—
	— Execution of end control including spool dimensions (and tolerances), markings, registration of findings — Correct sequence of process steps	—	In total 1	In total 1	—
T.7	Repair (where applicable) — Recognition of defects needing repair (e.g. impact, deep scratch, misalignment of flanges, incorrect execution of Joint Instruction) — Determination of repair needed — Execution of manufacturer's repair instruction(s), including appropriate QC, of repair types applicable to the certificate	In total 3	In total 3	In total 3	In total 3
	Total amount of questions	**34**	**44**	**44**	**42**
Minimum exam requirement: 70 % correct answers.					

Table C.7 — End terms — Practical exam

No.	Examination subjects. Subjects shall be correctly and independently executed by candidate.	Subjects per profession[a]			
		Pipe jointer	Spool-builder-A	Spool-builder-B	Pipe fitter
P.1	Production of pipe spool from pipe and joint[b] (as applicable for the certificate). The candidate shall correctly and independently — determine the required tool(s) and material(s), — execute manufacturer's joint instruction(s), — execute manufacturer's tool instruction(s),	√	√	√	√
Minimum exam requirement: — 100 % approved hold points on AOS; — 100 % correct answers on recorded questions[d]: — Joint(s) made by candidate shall pass the hydrotest. Optional: Joint(s) made by candidate shall pass the conductivity test. [a] √ means: check. [b] The purpose of this pipe spool is to perform a hydrostatic test on the joint(s). It is not the intention to produce a spool in accordance with tolerances shown in Table 1 and Table 2. Candidates that need to be able to work according to these tolerances shall be trained and examined in accordance with end terms P.2 and/or P.3. [c] In absence of actual construction work, assessor might use photos. [d] If the candidate fails on one question, the candidate shall be given a second change by asking one more question. If the candidate answers that question correctly, he/she will pass this section of the exam. If not, he/she will fail the exam.					

Table C.7 *(continued)*

No.	Examination subjects. Subjects shall be correctly and independently executed by candidate.	Subjects per profession[a]			
		Pipe jointer	Spool-builder-A	Spool-builder-B	Pipe fitter
	— register relevant data, apply relevant markings, and — work safely with necessary materials and tooling. Apply required PPE. Apply proper housekeeping.				
P.2	Production of pipe spool from pipe(s) and fitting(s) (as applicable for the certificate). The candidate shall correctly and independently — determine the required tool(s) and material(s), — produce a three-dimensional pipe spool from pipes and fittings, according to: — dimensions shown on isometric; — manufacturer's joint instruction(s); — manufacturer's tool instruction(s); — control dimensions of three-dimensional spool, — register relevant data, apply relevant markings, — work safely with necessary materials and tooling. Apply required PPE. Apply proper housekeeping.	—	√		—
P.3	Production of pipe spool from segmented pipe(s) and fitting laminate(s) (as applicable to the certificate). The candidate shall correctly and independently — determine the required tool(s) and material(s), — produce a three-dimensional pipe spool from segmented pipes and fitting laminates, according to: — dimensions shown on isometric; — manufacturer's fitting laminate procedure(s) (including instructions for segmenting); — manufacturer(s) tool instruction(s); — control dimensions of three-dimensional spool, — register relevant data, apply relevant markings, and — work safely with necessary materials and tooling. Apply required PPE. Apply proper housekeeping.	—	—	√	—
P.4	Work according to manufacturer's packing, storage and handling procedures	√	√	√	√
P.5	Work according to local construction safety requirements (where applicable)	√	√	√	√
P.6	Execute a (mill) hydrotest on a spool	—	√	√	—
P.7	Execute a field hydrotest on a pipe system	—	—	—	√

Minimum exam requirement:

— 100 % approved hold points on AOS;

— 100 % correct answers on recorded questions[d]:

— Joint(s) made by candidate shall pass the hydrotest.

Optional: Joint(s) made by candidate shall pass the conductivity test.

[a] √ means: check.

[b] The purpose of this pipe spool is to perform a hydrostatic test on the joint(s). It is not the intention to produce a spool in accordance with tolerances shown in Table 1 and Table 2. Candidates that need to be able to work according to these tolerances shall be trained and examined in accordance with end terms P.2 and/or P.3.

[c] In absence of actual construction work, assessor might use photos.

[d] If the candidate fails on one question, the candidate shall be given a second change by asking one more question. If the candidate answers that question correctly, he/she will pass this section of the exam. If not, he/she will fail the exam.

Table C.7 *(continued)*

No.	Examination subjects. Subjects shall be correctly and independently executed by candidate.	Subjects per profession[a]			
		Pipe jointer	Spool-builder-A	Spool-builder-B	Pipe fitter
P.8	Execute a conductivity test (where applicable)	√	√	√	√
P.9	Repair (where applicable): — Determine the need for, and required type of, repair. — Determine the required tool(s) and material(s). — Execute the repair according to manufacturer's repair instruction(s).	√	√	√	√
P.10	Installation: — Determine the required tool(s), material(s) and man-hours for a (small) specific job. — Inspect a) trench, b) backfill, c) supports[c]. — Register relevant data.	—	—	—	√
Minimum exam requirement: — 100 % approved hold points on AOS; — 100 % correct answers on recorded questions[d]: — Joint(s) made by candidate shall pass the hydrotest. Optional: Joint(s) made by candidate shall pass the conductivity test. [a] √ means: check. [b] The purpose of this pipe spool is to perform a hydrostatic test on the joint(s). It is not the intention to produce a spool in accordance with tolerances shown in Table 1 and Table 2. Candidates that need to be able to work according to these tolerances shall be trained and examined in accordance with end terms P.2 and/or P.3. [c] In absence of actual construction work, assessor might use photos. [d] If the candidate fails on one question, the candidate shall be given a second change by asking one more question. If the candidate answers that question correctly, he/she will pass this section of the exam. If not, he/she will fail the exam.					

Table C.8 — End terms — Representative diameters and pressure ratings

Representative product			Represented diameter range	
Joint type[a]	Diameter	Pressure	Diameter	Pressure
Conical-cylindrical bonded joint	DN ≤ 200 DN > 200	PN	25 to 2DN 0,5DN to 2DN	≤PN
Taper-taper bonded joint				
Laminate joint				
Threaded joint				
Mechanical O-ring lock joint	DN	PN	25 to 2DN	any PN
Mechanical O-ring joint				
Flange joint				
[a] See Table C.4: Product-related definitions.				

Table C.9 — End terms — Hydrostatic test

Procedure	In accordance with ASTM D1599, with the following exceptions: — The time to failure requirement does not apply. — The test pressure shall be held for 1 hour. — The test shall be performed at ambient temperature. — The length of each test piece shall be in accordance with ASTM D1599. — The test shall be performed with free ends in such a way that the joint is exposed to stresses in both axial and hoop directions. — Both pressure and time of the hydrotest shall be recorded. — The report shall include photo(s) of the joint, taken direct after the hydrotest, showing compliance or non-compliance with the test requirement (no leakage[a]).	
Test pressure	Pre-described threaded joints:	2 times PN
	Other joints:	2,5 times PN[b]
Pass/fail requirement	No leakage or separation of the joints shall be observed.	

[a] To register this test requirement, a dry carton may be placed under the tested joint.

[b] For flanged joints the gasket might be a limiting factor. In that case, the test pressure is limited to 1,5 times the rated pressure. This note does not apply for flanges used as end closure.

Table C.10 — End terms — Conductivity test (optional)

Procedure	As specified in ISO 14692-2:2017, 7.3.1
Pass/fail requirement	

Table C.11 — Assessment observation sheet (AOS) (informative)

C.11.1 — Type				
Profession (per Table C.1)		Pipe jointer		
Joint type (per Table C.4)		Taper/taper adhesive bonded joint		
C.11.2 — Checklist with hold points (to be filled in by jointer)				
C.11.2.1 — GRP product data				
Nr.	**Check point**	**Finding**		
1	Manufacturer's name			
2	Product series			
3	Pressure class			
4	Nominal diameter	mm/inch		
5	Drawing number		☐ Not Relevant	
6	Joint identification		☐ Not Relevant	
7	Unique identification number on section containing spigot end			
8	Unique identification number on section containing socket end			
C.11.2.2 — Inspection				
Nr.	**Check point**	**Finding**		
1	Check spigot part on damages (impact, scratch, blister, etc.)	☐ OK	☐ Not OK	
2	Check socket part on damages (impact, scratch, blister, etc.)	☐ OK	☐ Not OK	
3	Check for damage of containers adhesive components	☐ OK	☐ Not OK	
4	Check expiry date of adhesive	Date (dd-mm-yyyy):		
5	Check batch number(s) adhesive kit	Batch nr(s):		

Table C.11 *(continued)*

C.11.2.3 — Tools/miscellaneous				
Nr.	**Check point**	**Finding**		
1	Shaver identification	Type:	Number:	
2	Inspect shaver and power drive on completeness/safety	☐ OK	☐ Not OK	☐ Not Relevant
3	Required taper angle spigot end (degrees)			☐ Not Relevant
4	Set shaver/adjust to the required taper dimensions	☐ OK	☐ Not OK	☐ Not Relevant
5	Select correct heating blanket (type, size, voltage)	☐ OK	☐ Not OK	
6	Select correct temperature controller (type, voltage)	☐ OK	☐ Not OK	☐ Not Relevant
7	Check availability of correct and proper tools	☐ OK	☐ Not OK	
8	Check availability of correct type of adhesive	☐ OK	☐ Not OK	
9	Check required quantity of adhesive per joint	☐ OK		g/kit
10	Check compliance health/safety requirements (PPE)	☐ OK	☐ Not OK	
C.11.2.4 — Ambient environment				
Nr.	**Check point**	**Finding**		
1	Ambient temperature			°C
2	Relative humidity			%
3	Dew point			°C
4	Precipitation (e.g. rain/ snow/ hail)	☐ Yes	☐ No	
5	Sheltered environment required	☐ Yes	☐ No	
Hold point C.11.2.1 — C.11.2.4				
Continuation after approval of check points per Table C.11.2.1 to C.11.2.4		JOINTER	☐ Approved	☐ Not Approved
		ASSESSOR	☐ Approved	☐ Not Approved
C.11.2.5 — Dimensioning of spigot (if applicable)				
Nr.	**Check point**	**Finding**		
1	Clean the pipe to cut	☐ OK	☐ Not OK	
2	Cut the pipe and check the squareness	☐ OK	☐ Not OK	
3	Find the required insert depth (minimum insert depth/ maximum insert depth)	Minimum	Maximum	mm
4	Find the required nose thickness (T nom)	mm		
5	Find maximum allowable tolerance nose thickness (Tol max)	mm		
6	Shave the spigot	☐ OK	☐ Not OK	
7	Mark and measure actual insert depth	mm		
8	Check nose thickness (T min/T max)	T min	T max	mm/inch
9	Check actual tolerance nose thickness	Tol act	mm	
10	Check eccentricity	☐ OK	☐ Not OK	
11	Scribe alignment/orientation mark and insertion mark on Y = minimum depth insert + X	☐ OK	☐ Not OK	X = mm
12	Check compliance health/safety requirements (PPE)	☐ OK	☐ Not OK	
Hold point C.11.2.5				
Continuation after approval of check points per Table C.11.2.5		JOINTER	☐ Approved	☐ Not Approved
		ASSESSOR	☐ Approved	☐ Not Approved

Table C.11 *(continued)*

C.11.2.6 — Preparing for bonding (sheltered if required)				
Nr.	**Check point**	**Finding**		
1	Dry and clean bonding surfaces of spigot and bell	☐ OK	☐ Not OK	
2	Condition (sheltered) environment according requirements (temperature, humidity, dew point)	Temperature °C	Humidity %	Dew point °C
3	Temperature bonding surface spigot			°C
4	Temperature bonding surface bell			°C
5	Sand bonding surfaces of spigot and bell maximum 2 hours from assembly	☐ OK	☐ Not OK	
6	Break sharp edges	☐ OK	☐ Not OK	
7	Clean sanded surfaces of spigot and bell	☐ OK	☐ Not OK	
8	Time finishing sanding (hrs, min.)	Time:		
9	Mount pulling equipment	☐ OK	☐ Not OK	
10	Temperature adhesive components			°C/°F
Hold point C.11.2.6				
Continuation after approval of check points per Table C.11.2.6		JOINTER	☐ Approved	☐ Not Approved
		ASSESSOR	☐ Approved	☐ Not Approved
C.11.2.7 — Bonding				
Nr.	**Check point**	**Finding**		
1	Time mixing components adhesive finished (hrs, min.)	Time:		
2	Time start applying adhesive on bonding surfaces (hrs, min.)	Time:		
3	Apply adhesive layer on bonding surface bell	☐ OK	☐ Not OK	
4	Apply adhesive layer on bonding surface spigot	☐ OK	☐ Not OK	
5	Pull spigot into bell and check alignment/orientation and insertion depth (max) X	☐ OK	☐ Not OK	X = mm
6	Time after insertion spigot in bell (hrs, min.)	Time:		
7	Check correctness support	☐ OK	☐ Not OK	
8	Remove excessive adhesive	☐ OK	☐ Not OK	
9	Mount heating blanket, insulation, temperature gauge and switch power on	☐ OK	☐ Not OK	
10	Check required curing time, mark start of curing time and temp. next to joint (after heating up)	Time:		°C
11	Check curing temperature, mark time end of curing next to joint (switch power off)	Time:		°C
Hold point C.11.2.7				
Continuation after approval of check points per Table C.11.2.7		JOINTER	☐ Approved	☐ Not Approved
		EXAMINER	☐ Approved	☐ Not Approved

C.11.3 Assessment observations (to be filled in by assessor)			
C.11.3.1 — Attitude			
Use of PPE	☐ OK	☐ NOT OK	Remarks:
Behaviour	☐ OK	☐ NOT OK	Remarks:
Ability	☐ OK	☐ NOT OK	Remarks:
Use of checklist	☐ OK	☐ NOT OK	Remarks:

Table C.11 *(continued)*

C.11.3.2 — Questions				
	Question	Answer		
Question 1				
		☐ OK	☐ NOT OK	
Question 2				
		☐ OK	☐ NOT OK	
Question 3				
		☐ OK	☐ NOT OK	☐ N/A
C11.3.3 — Exam results (include evidence)				
Theoretical exam	☐ OK	☐ NOT OK		
Practical exam	☐ OK	☐ NOT OK		
Hydro test	☐ OK	☐ NOT OK		
Conductivity test	☐ OK	☐ NOT OK		
C11.3.4 — Approved for successful assessment				
By assessor	☐ OK	☐ NOT OK		
By internal verifier	☐OK	☐ NOT OK		
C11.3.5 — Endorsement				
	ASSESSOR	**INTERNAL VERIFIER**		
Name:				
Signature:				
Date:				

C.2.4 Assessment requirements for trainer/assessor/internal verifier and facilities

C.2.4.1 Minimum experience requirements

The candidate trainer/assessor/internal verifier shall understand the language in which the course is being conducted. The candidates shall be in satisfactory physical condition and shall have eye sight which fulfils either of the following requirements:

a) ISO 9712 or equivalent and have an eyesight test every 12 months, or

b) unaided or corrected near visual acuity in at least one eye, such that the candidate is capable of reading N4 Times Roman type at a distance of not less than 30 cm on a standard reading test.

In order to be admitted for assessment, the trainer/assessor/internal verifier shall be at least 21 years of age and fulfil either of the following minimum experience requirements.

— Trainer — Same as pipe jointer/spoolbuilder A or B/pipe fitter, all as applicable to the training. One year experience in GRP piping installation or equivalent

— Assessor — Same as trainer

— Internal verifier — QA manager

In order to be admitted for assessment, the training and examination facility shall:

a) be equipped with adequate HSE provisions;

b) provide adequate working space for the number of candidates trained/examined simultaneously;

c) enable authentic work of the candidates during both theoretical and practical exam.

C.2.4.2 Proficiency assessment of trainer/assessor

The assessment organization decides on issuing a certificate of proficiency to the candidate trainer/assessor based on the result of the theoretical exam, as well as the reported findings of the external verifier and competence committee delegate as described below.

The candidate trainer/assessor shall be trained and assessed on both technical and procedural competence, in accordance with the applicable parts of C.2 with the following additions/deviations.

a) The training committee is responsible for the technical training of candidate, i.e. takes the role of "trainer" of candidate trainer/assessor.

b) The competence committee is responsible for the technical assessment of candidate, i.e. takes the role of "assessor" of candidate trainer/assessor.

c) The assessment organization is responsible for both training and assessment of procedural competence of candidate trainer/assessor.

d) The candidate is to receive introduction to pipe and fitting production and assist winder operator, where possible. The candidate is to receive introduction to QA/QC system and assist QC inspector with in-process control and dimensional control.

e) The candidate is to receive training on site installation issues and experiences, installation manuals, basic explanation of both product and system design, introduction to stress analysis.

f) The candidate is to be assessed, both theoretical and practical, in accordance with C.2.2.9 and C.2.2.10, on one diameter per profession and joint type. The number of questions per theoretical exam shall be three times the numbers stated in Table C.6. The maximum theoretic exam duration shall be 4 hours. The minimum theoretic exam requirement is 90 % correct answers. Candidate to perform a hydrotest on each joint in accordance with Table C.9.

g) The candidate shall train and assess (a) jointer(s) or other profession per Table C.1 (as applicable to the aimed certificate of candidate trainer/assessor), in accordance with C.2 and in front of external verifier and competence commission delegate. During this session, the candidate shall be assessed on the following subjects:

   1) technical competence, by competence commission delegate;

   2) procedural competence, by external verifier from assessment organization;

   3) training abilities, by competence commission delegate and external verifier.

C.2.4.3 Proficiency assessment of internal verifier

The assessment organization decides on issuing a certificate of proficiency to the candidate internal verifier based on the reported findings of the external verifier.

The candidate internal verifier shall be trained and assessed on procedural competence, in accordance with the applicable parts of C.2, with following additions/deviations.

a) The internal verifier shall be audited on compliance with this annex by the external verifier.

b) The candidate shall act as internal verifier during the assessment described in C.2.4.2, in the presence of the external verifier. During this session, the candidate shall be assessed on the following subjects:

   1) procedural competence, by external verifier from assessment organization;

   2) verifying abilities, by external verifier from assessment organization.

C.2.5 Contents of certificate

C.2.5.1 Contents of trainer/assessor certificate

The trainer/assessor certificate shall contain the following information:

a) family name, initials and photo of certificate holder;

b) date and place of birth;

c) place of examination;

d) date of successful assessment and expiry date;

e) scope of trainer/assessor, i.e. professions and joint types that certificate holder is allowed to train/assess, that is the following:

   1) applicable profession, i.e. pipe jointer, spoolbuilder-A, spoolbuilder-B and/or pipe fitter;

   2) applicable joint type(s) as specified in Table C.4;

   3) applicable conductive products;

   4) applicable repair type(s).

f) reference to this annex;

g) assessment organization's stamp and signature;

h) candidate's signature.

C.2.5.2 Contents of internal verifier certificate

The internal verifier certificate shall contain the following information:

a) family name, initials and photo of certificate holder;

b) date and place of birth;

c) place of examination;

d) date of assessment and expiry date;

e) reference to this annex;

f) assessment organization's stamp and signature.

C.3 Supervisor training course

C.3.1 Qualifications and experience

For acceptance into the supervisor course, the candidate shall have a minimum of 2 years' experience in GRP pipe bonding, spoolbuilding or pipe fitting and should preferably be in possession of the relevant qualification certificate. The experience of the candidate shall ideally include all the commonly used joining techniques, e.g. adhesive bonding, laminating and various types of mechanical connections.

Other documented evidence of education, training and experience may be considered to give equivalent competence.

Candidates shall be in satisfactory physical condition and shall have eyesight that fulfils the requirements of C.2.2.

C.3.2 Role of the supervisor

The supervisor monitors and has the responsibility for the execution of the work, by the bonders, spoolbuilders and pipe fitters, during both the production and installation phase. The supervisor monitors and ensures that bonders, spool builders and pipe fitters and others, are working according to the relevant HSE requirements, (quality) standards, procedures and (where applicable) system design and monitors progress in relation to a given time frame.

C.3.3 Main responsibilities

The main responsibilities of the supervisor are as follows:

a) monitoring compliance of the work within the quality requirements (site quality plan);

b) identifying quality problems and recommending corrective actions or solutions;

c) regularly reporting and documenting the progress of the work and including the final report according to health and safety regulations, installation instructions and pipe system design;

d) instructing of the fitters and monitoring of the work;

e) monitoring the thoroughness of the GRP piping system installation and accessories;

f) monitoring the activities of the jointers and verifying that they are working according to the HSE requirements, standards, procedures and (where applicable) system design;

g) verifying documentation and materials;

h) monitoring that the work is performed according to local legislation.

C.3.4 Knowledge requirements

The main knowledge requirements of the supervisor are as follows:

a) GRP pipe products and applications theoretical, as well as practical;

b) applicable quality systems;

c) installation and testing techniques of GRP piping systems theoretical, as well as practical;

d) materials used during installation theoretical, as well as practical, especially with reference to laminated joints, adhesive joints, o-rings, locking keys, threaded joint, etc.;

e) GRP piping and pipeline system design;

f) transportation, handling and storage techniques of GRP piping components;

g) maintenance and repair techniques of GRP piping systems;

h) HSE regulations and applicable local legislation.

C.3.5 Skills requirements

The main skill requirements of the supervisor are as follows:

a) reading drawings, including isometrics;

b) project planning;

c) organization;

d) instructions;

e) reporting;

f) communication;

g) interpersonal relations;

h) command of the language of the procedures;

i) working with tools;

j) working with a computer.

C.3.6 Training

As a minimum, the supervisor training course shall include the following:

a) the supervisor's duties and responsibilities;

b) health and safety aspects;

c) installation check list:

   1) transport and storage;

   2) preparation, assembly and finishing of main joint types;

   3) installation details, e.g. engineering, pipe supports, damage prevention, etc.;

   4) hydrotest and leak test;

   5) repair procedures;

d) inspection of pipe and joints;

e) handling/fitting of pipe.

C.3.7 Examination and qualification

The candidate shall become qualified as a supervisor on successful completion of the following:

a) attendance at the course;

b) an examination on the topics covered in the course witnessed and assessed by the recognized assessment organization.

C.3.8 Validity and renewal

C.3.8.1 Validity

The supervisor qualification certificate (issued by the assessment organization) shall be valid for a period of 5 years from the date of successful completion of the original examination.

C.3.8.2 Renewal

For renewal of the supervisor certificate, a minimum of 25 weeks of authenticated active work with GRP pipe installation supervision during the 5-year validation period is required. Of these, a minimum of 10 weeks shall be within the last 2 years.

C.4 Inspector training course

C.4.1 Qualifications and experience

The candidate should be aged 25 years at the minimum, and should fulfil at least one of the following experience requirements:

a) as a qualified GRP supervisor, a minimum of 1 year of experience;

b) as a qualified GRP pipe fitter/jointer, a minimum 3 years of experience.

Other documented evidence of education, training and experience may be considered to give equivalent competence.

Candidates shall be in satisfactory physical condition and shall have eyesight which fulfils either of the following requirements:

— ISO 9712 or equivalent and have an eyesight test every 12 months; or

— unaided or corrected near visual acuity in at least one eye such that the candidate is capable or reading N4 Times Roman type at a distance of not less than 30 cm on a standard reading test.

C.4.2 Role of the inspector

The inspector monitors independently the installation of the GRP piping system and verifies that the supervisor, bonders, spoolbuilders, pipe fitters are working according to the health and safety requirements, standards, procedures and (where applicable) system design.

The inspector will execute the final system check and reports as an (independent) expert his findings to the principal concerning the installation.

C.4.3 Main responsibilities

The main responsibilities of the inspector are as follows:

a) verifying documentation and materials;

b) monitoring of the activities of the supervisors, bonders, spoolbuilders, pipe fitters and verifying if they are working according to the (health and safety) requirements, standards, procedures and (where applicable) system design;

c) identifying quality problems and recommending corrective actions or solutions;

d) regularly reporting and documenting of the qualitative progress to the principal;

e) monitoring if the work is performed according to local legislation;

f) inspecting the completed installations within the responsibility of a supervisor;

g) supplementary inspections and reports.

C.4.4 Knowledge requirements

The inspector should have the same knowledge level as the supervisor, although he does not need to be a “hands-on” practical man to the same high level as a supervisor. He shall be able to judge and assess the work of the bonders, spool builders, pipe fitters and supervisor.

Regarding the knowledge level, the following additional supplements are required:

a) GRP pipe products regarding installation and reviewing of GRP piping systems;

b) materials for, e.g. laminated joints, adhesive joints, O-rings, locking key, etc.;

c) system design with respect to installation issues;

d) development of traceability procedures;

e) the applicable quality systems and procedures, including requalification of adhesives;

f) GRP pipe specifications.

C.4.5 Skills requirements

The main skill requirements of the inspector are as follows:

a) understanding technical drawings, including isometrics;

b) organization;

c) instructions;

d) reporting;

e) interpersonal skills;

f) command of the language of the procedures;

g) working with tools;

h) working with a computer.

C.4.6 Training

The inspector course shall give a theoretical and practical introduction into the most important elements of inspection of a GRP pipe system. The preferred course duration is a minimum of 3 days and it should include, but not be limited to, the following:

a) repetition of elements for the pipe fitter course;

b) inspection of received goods;

c) inspection before, during and after assembly of main joint types;

d) inspection of support;

e) inspection of repair;

f) hydrostatic testing;

g) destructive and non-destructive testing methods;

h) general inspection and the inspector's duties and responsibilities;

i) written procedures, documentation and reporting.

The candidate shall perform five different inspections, including electrical continuity of the main joint types and fittings including pipe-to-fitting, as well as pipe-to-pipe joints.

C.4.7 Examination and qualification

The candidate shall become qualified as an inspector on successful completion of the following:

a) attendance at the course;

b) an examination on the topics covered in the course witnessed and assessed by the recognized assessment organization.

C.4.8 Validity, renewal and withdrawal of approval

C.4.8.1 Validity

The inspector qualification certificate (issued by the assessment organization) shall be valid for a period of 5 years from the date of original examination.

C.4.8.2 Renewal

For renewal of the inspector qualification certificate, a minimum of 25 weeks of authenticated active work with GRP pipe installation inspection during the 5-year validation period is required. Of these, a minimum of 10 weeks shall be within the last 2 years.

Annex D
(informative)

Guidance for use of jointing methods

D.1 General

Guidance is presented for the following types of thrust-resistant types of joint (restrained joint):

a) adhesive-bonded joint;

b) elastomeric seal lock joint;

c) laminated joint;

d) flanged joint;

e) threaded joint.

The designer should take into account the following factors when selecting the jointing method:

— criticality (reliability);

— performance under axial (bending) loads;

— installation environment (ease of inspection);

— ease of fabrication.

The workmanship involved in the make-up of any of the above mentioned joints should not be overlooked. It is imperative that appropriate supervision of all tasks involved in the make-up of the joint is ensured and that the appropriate QA checks as defined are followed in strict accordance.

D.2 Adhesive-bonded joints

D.2.1 Description

The adhesive-bonded joint consists of a tapered bell end and a tapered or cylindrical spigot end, bonded with an adhesive/hardener mixture (see Figure D.1). Alternatively, the bell-and-spigot may be taper-threaded.