NORSOK STANDARD M-622

Rev. 1, April 2005

Fabrication and installation of GRP piping systems

Standards Norway
Strandveien 18, P.O. Box 242
N-1326 Lysaker
NORWAY

Telephone: + 47 67 83 86 00
Fax: + 47 67 83 86 01
Email: petroleum@standard.no
Website: www.standard.no/petroleum

Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Annex A and B are normative.

Introduction

This NORSOK standard replaces NORSOK M-630, MDS P-01, and NORSOK M-CR-621. This NORSOK standard is based upon ISO 14692 (all parts), but extended with sections on quality control and NDT including two annexes describing ultrasonic and radiography testing, respectively.

1 Scope

This NORSOKstandard specifies additional and optional requirements to ISO 14692 (all parts). All components that form part of a GRP piping system (e.g. pipe, branches, bends, tees, flanges, and joints) are covered.

This NORSOK standard is directed towards piping systems in GRP materials used on offshore production platforms, but may also be used for similar onshore systems.

2 Normative and informative references

The following standards include provisions and guidelines which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

2.1 Normative references

ASTM D1599-99e1,	*Standard Test Method for Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings*
EN 473	*Non-destructive testing – Qualification and certification of NDT personnel – General principles*
ISO 14692-1,	*Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 1: Vocabulary, symbols, applications and materials*
ISO 14692-2,	*Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 2: Qualification and manufacture*
ISO 14692-3,	*Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 3: System design*
ISO 14692-4,	*Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 4: Fabrication, installation and operation*
DIN 16965-2,	*Wound glass fibre reinforced polyester resin (UP-GF); pipes, Type B pipes, dimensions*
DIN 16966-1,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joint assemblies; fittings; general quality requirements and testing*
DIN 16966-2,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joints; Elbows, Dimensions*
DIN 16966-4,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joints; Tees, Nozzles, Dimensions*
DIN 16966-5,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joints; Reducers, Dimensions*
DIN 16966-6,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joint assemblies; collars, flanges, joint rings, dimensions*
DIN 16966-7,	*Pipe joints and their elements of glass fibre reinforced polyester resins – Part 7: Bushings, flanges, flanged and butt joints; general quality requirements and test methods*
DIN 16966-8,	*Glass fibre reinforced polyester resin (UP-GF) pipe fittings and joints; Laminated joints; Dimensions*
NTS-GRP-FJS/01,	*Certification of personnel for installation of composite pipes*
NTS-GRP-Insp/01,	*Certification of inspectors for installation of composite pipes*
KRV A 984/82-2,	*Kunststoffrohrverband (KRV); "GFK-Industrierohre".*

2.2 Informative references

NORSOK M-630,	*Material data sheets for piping*
NORSOK M-CR-621,	*GRP piping materials*

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
shall
verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.2
should
verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.3
may
verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.4
can
verbal form used for statements of possibility and capability, whether material, physical or casual

3.2 Abbreviations

DN	nominal diameter
DSC	differential scanning calorimeter
DWSI	double wall single image
ECR	glass fibre grade with good chemical resistance in acidic environment
EX	classification of explosion hazards
GRE	glass-fibre reinforced epoxy
GRP	glass-fibre reinforced plastic
NDT	non-destructive testing
PE	pulse echo
PED	Pressure Equipment Directive
RT	radiographic testing

4 Pressure equipment directive (PED)

The manufacturer and the installation contractor shall satisfy the requirements given in European Pressure Equipment Directive (PED), when applicable.

NOTE The European implementation of ISO 14692 (all parts) is so far not a harmonised standard according to PED. In those applications where PED is governing, it is therefore necessary to apply the directive and to use a notified body to approve all stages in the process from design to installation.

5 Qualification and manufacture

Reference is made to ISO 14692-2.

Section 5 Materials of construction
The recommended materials of construction dependent of the fluid to be transported in piping systems are listed in Table 1. The final selection has to be agreed between the selected manufacturer and the Company.

Table 1 - The recommended materials for use in pipe construction dependent of fluids to be transported

Service	Structural part	Inner liner
Service water Process water Cooling medium/water Sewage/grey water Non-hazardous drain Non-hazardous vent Fire water ring main Fire water dry deluge Fire water wet deluge Produced water Ballast water	Bisphenol A epoxy resin [a] reinforced with E-glass.	Bisphenol A epoxy resin [a] reinforced with ECR-glass fibres and surface veil of C-glass fibres or synthetic fibres.
Potable water	Bisphenol A epoxy resin [a] reinforced with E-glass.	According to the national health or certifying authorities in the country of use.
Hydrochloric acid	Bisphenol A epoxy resin [a] reinforced with ECR-glass.	Bisphenol A epoxy resin[1)] reinforced with ECR-glass.
Concentrated sodium hypochlorite and sulphuric acid	Chemical resistant laminate	Thermoplastic liner [b]

[a] Aromatic or cyclo-aliphatic curing agents shall be used. An alternative is to use vinylester resin. In special cases other resins may be used.

[b] Requirements related to thermoplastic liner material and lined pipes shall be according to DIN 16965-2 and DIN 16966 (all parts), pipe type B. Requirements for jointing of thermoplastic lined pipes shall be according to KRV A 986/82-2.

Section 8.3.4 Optional short-term burst tests

Short-term burst tests shall be performed for pipe components intended for NDT group 3 services (see Table 3) unless otherwise agreed with the party that initiates the project and ultimately pays for its design and construction (principal). The test frequency shall be minimum 1 % of the total number of components produced and all component types shall be included. The p_{STHP} shall be determined in accordance with ASTM D1599-99e1 at standard laboratory temperature.

6 Fabrication of spools and piping systems

6.1 Inspection strategy

Contractor shall establish an inspection strategy and programme with procedures for the construction and operation phase for each new project (contract), which shall be sent to company for acceptance. The inspection strategy and programme can be based on previously developed strategy and an accompanying programme. The inspection programme shall reflect the system criticality as defined in Table 3.

In projects where more than one set of Regulatory Authorities' rules apply or several contractors are involved, only one inspection strategy and one common inspection programme shall apply for the GRP piping system.

6.2 Inspection in operation

The GRP piping systems shall be inspected within the first year (group 2 and group 3 systems) and within the second year (group 1) after start of service. The inspection interval thereafter shall be 1 year to 2 years for group 2 system and group 3 system and 3 years for group 1 systems. The inspection intervals shall be adjusted, i.e. reduced or increased depending on observed severe degradation or gained confidence in materials and construction. An increase of inspection intervals can be considered after 5 years of service.

Destructive testing is required if the service life is extended beyond the originally estimated service life.

6.3 Requirements to fabrication and installation

Reference is made to ISO 14692-4.

Section 5.4 Installer requirements

Pipe fitters, supervisors and inspectors shall be exclusively qualified and certified for specific joint type. As a minimum, it is required that the pipe fitters, supervisors and inspectors are certified according to GRP guideline no. NTS-GRP-FJS/01, and GRP guideline no. NTS-GRP-Insp/01.

NOTE As an alternative, for work that is done outside Norway or the Norwegian sectors the pipe fitters, supervisors and inspectors may be qualified in accordance with another internationally recognised certification scheme based on acceptance by the company.

Section 5.5.4 Installation

Add new section as follow:

5.5.4.6 Quality control of prefabricated spools

Prefabricated spools shall be leak or pressure tested according to the extent and pressures as defined in Table 2. The hydrostatic pressure shall be maintained for a minimum of 5 min for both the leak and pressure test.

Table 2 - The pressure test requirements as quality control of prefabricated GRP piping spools

NDT Group [a]	Pressure testing requirements	
	Extent	Type of test
1	10 %	Leak test [b]
2 and 3	10 %	Pressure test [c]

[a] NDT groups are defined in table 3.
[b] Test pressure shall be 1,1 x maximum allowable operating pressure.
[c] Test pressure shall be according to requirements in ISO 14692-4. It is recommended to perform the pressure testing at an early stage of the prefabrication so, if needed, remedial actions can be taken.

In case of failure, retest shall be performed according to the requirements in ISO 14692-2, 8.3. Pipe spools that are prefabricated for replacement work shall be pressure tested before being installed, if possible.

Section 5.5.6.2 Quality control of adhesive and laminated joints

Add new section as follow:

Section 5.5.6.2.1 Definition of NDT groups

The definition of applicable NDT groups, dependent of fluid service and design pressure, and extent of radiographic and adhesive cure testing, for prefabricated spools and installed piping systems are defined in Table 3.

Table 3 - The definition of NDT groups and required minimum extent of inspection for joints in GRP piping systems

NDT Group	Service	Design pressure bar	Extent of NDT [a] [b]	
			RT [c] [d] %	DSC [d] %
1	Open drain; sea water supply	< 10	0	0
2	Sea water, produced water	< 20	5	5
	Cooling water, fire water, ballast water	< 40		
3	Chemicals, acids and hydrocarbon fluids	< 40	10	10

[a] Percentages shall be based on total number of joints in a piping system made by the same joining method.
[b] 50 % of the specified minimum non-destructive examination shall be performed on prefabricated joints. Minimum four prefabricated joints and minimum four field joints shall be tested whenever NDT is specified. Each fitter shall be represented.
[c] The RT is only applicable to joints made by the adhesive bond joining method, thus RT is not applicable to joints made by the lamination method. RT may be replaced with ultrasonic testing provided if qualified and approved by the company. The percentage of extent shall be doubled.
[d] When required spot or random inspection reveals a defect, two additional joints of the same kind from the same lot as defined in [a], shall be inspected. If any of these two joints reveals a defect, two further joints of the same kind as above, shall be inspected. If any of these reveals a defect all joints within the lot shall be inspected. All joints found defective shall be repaired or replaced and re-inspected.

Visual inspection shall be performed of all surfaces and joints of prefabricated spools and installed piping systems. The acceptance criteria shall at all stages be according to ISO 14692-4, Annex A.

The performance of radiographic testing and alternative ultrasonic testing shall be according to procedure established according to Annex A and B. The related acceptance criteria shall be according to Annex A and Annex.

All joints made with vinylester or polyester resin shall be 100 % Barcol hardness tested.

Section 5.6.2.3 Testing
After a successful pressure-decay test a further leak test as defined in ISO 14692-4 shall be carried out on all system.

ISO 14692-4, Annex C, Guidance for use of jointing methods
ISO 14692-4, Annex C, shall be normative for joining methods.

Add new sections:

Section C.2.5 and C 3.5 Curing
For epoxy based products the glass transition temperature (T_G) of the cured adhesive or resin shall not be less than 95 % of the minimum value quoted by the manufacturer for the adhesive or resin system. Depending on the measured T_G value scenarios, the actions listed in Table C.1 shall be implemented.

Table C.1 - Actions required depending on measured T_G value in first (T_{G1}) and second scan (T_{G2})

Scenario	T_{G1} value	T_{G2} value	Corrective action
1	Low	Low	Reject
2	Low	High	Repeat curing
3	High	High	OK

Annex A
(Normative)
Ultrasonic testing

A.1 Main detectable defects

A.1.1 General

Main detectable defects are

- areas in bonded pipe joints lacking adhesive,
- delaminations,
- voids,
- deviations in wall thickness.

A.1.2 Limits of detect ability

The lacking adhesive defect area shall have a diameter of approximately 10 mm or larger in order to be detected and the wall thickness shall be smaller then 100 mm. Areas of poor adhesion (i.e. “kissing bonds”) will not be reliably detected by this method. Delaminations can be detected with similar resolution as for voids. Variations in wall thickness of 5 % to 10 % can also be detected. The detection limits are dependent on method, equipment and frequency.

A.1.3 General

A.1.3.1 Methods

The PE method (where one transducer functions as both transmitter and receiver) is the most commonly used ultrasonic test method for GRP. In addition, through-transmission (using two transducers) and impedance plane methods (one transducer with phase monitoring) have been successfully used.

A.1.3.2 Probes

Probe selection should recognise the trade-offs between resolution (typically improved at higher frequencies, i.e.> 2,25 MHz), depth penetration (typically best a lower frequencies, i.e. < 2,25 MHz), signal damping characteristics, and diameter (larger diameters allow higher energy input, but at the expense of spatial definition of defects and successful coupling to curved surfaces).

Use of back-wall echoes is recommended for inspecting adhesively bonded joints since missing adhesive will cause the back-wall signal to disappear.

The quality of the surface finish will affect coupling and ultrasonic results. Results may be improved by use of coupling agents (e.g. water, gels, etc.) or by smoothing the surface. Single point inspections are not recommended due to the uncertainties associated with coupling, surface finish, and materials fabrication. Scanning devices (or multiple point inspections) are recommended because the resulting maps are easier to interpret, and because one inaccurate reading will not lead to wrong conclusions about the quality of the GRP joint/product.

A.1.3.3 Attenuation

Because of much greater attenuation in GRP compared to steel ultrasonic frequencies shall be reduced. A relatively low frequency, typically between 0,25 MHz and 2,25 MHz, is considered to be best suited for PE ultrasonic testing of GRP where the wall thickness is typically in the range 8 mm to 25 mm.

Reflected pulses in GRP have more complex waveforms and less time separation between the reflected pulses than is the case for steel. Therefore multiple echoes cannot reliably be used in signal interpretation.

Two methods for increasing the time between reflected signals are

- transmission through flooded GRP pipes with the signal returning from the opposite pipe wall,
- using a suitable standoff material (polymethacrylate).

The speed of sound in GRP (2 000 m/s to 4 000 m/s, with most quoted values for GRP pipes ranging from 2 700 m/s to 3 000 m/s) also differs from that of steel (6 000 m/s). This is important to remember when calibrating the equipment.

A.1.4 Acceptance criteria for lacking adhesive or adhesion

Due to the difference in local stress distributions in a taper/taper and taper/cylindrical joint the acceptance criteria will be different for the two joint types.

The following acceptance criteria shall apply when either voids or poor adhesion is present:

- total defect area shall be < 25 % of total joint area;
- the non-defective axial adhesive length shall be > 50 % of total joint length;
- taper/cylindrical: no defect intersecting the inside edge (nose) of the joint and a defect intersecting the outside edge shall be < 30 % of total joint length (up to 200 mm DN) and < 10 % of total joint length (from 200 mm to 600 mm DN). Largest stresses on the inside of joint.
- taper/taper: no defect intersecting the outside edge of the joint and a defect intersecting the inside edge shall be < 30 % of total joint length. Largest stresses on the outside of joint.

A.2 Inspection procedure for ultrasonic inspection of adhesively bonded fibre glass pipe joints

A.2.1 Scope

This procedure describes the requirements for ultrasonic testing of GRP piping systems and tanks. It applies to both automatic and manual scanning, and to both pulse-echo and impedance plane methods.

A.2.2 General requirements

The NDT inspectors shall be qualified according to EN 473, level 2 or equivalent. Additionally, they shall also have had specific training for GRP pipe joints in the ultrasonic test method to be used.

NDT inspectors of joints in piping systems falling into category III and IV (equipment/vessels) according to PED, shall be approved by a 3rd party organisation recognised by an European Common Market (EC) member state. Fibreglass pipe joints inspected with this procedure shall have a clean, smooth and uniform exterior surface. The surface shall be in a state that gives repeatable, stable signals when the probe is placed on the surface of the tested material. If the surface roughness is too large, a power driven sander with grade 80 sand papers can be applied to the exterior joint surface. The sanded surface shall be cleaned and dried before inspection. The sanded surface shall be sealed with a thin layer of epoxy or polyester for protection of the exposed fibres after inspection has been completed.

Ultrasonic techniques may be used to measure laminate thickness. The number of thickness measurements shall be as needed to provide for adequate calibration of equipment (e.g. ultrasonic impedance unit) or as desired to quantify potential erosion, wear, define conical surfaces, etc.

All defects found shall be drawn on the laminate surface with permanent ink.

A.2.3 Equipment

The ultrasonic unit to be used for the inspection shall be portable and rugged enough for the intended service. Equipment intended for laboratory use will normally not be suitable for field use. In particular moisture is detrimental. If outdoor testing is performed, the necessary precautions shall be taken to protect the equipment from rain, wind etc.

Most offshore platforms have EX 1 zones, in which no electric equipment that can produce sparks, are allowed. The operator of the equipment shall ensure that the equipment to be used fulfils the EX requirements, or obtain special permission from the safety department on board to execute the inspection in special zones, in shutdown periods etc.

A.2.4 Calibration

A.2.4.1 Calibration standard

A calibration standard shall be fabricated for each size and type of piping system to be inspected. The calibration standard shall be matched to the various types of defects to be found.

Variations in wall thickness should be calibrated using a portion of a pipe or joint laminate with a machined (milled) area on the interior surface equivalent to the desired defect resolution, but not smaller than 10 mm in diameter as shown in Figure A.1.

Pipe segment showing simulation of voids and delaminations in the GRP material or in the adhesive bond line. Defects achieved by machining holes with diameter and depth selected to match defects to be detected.

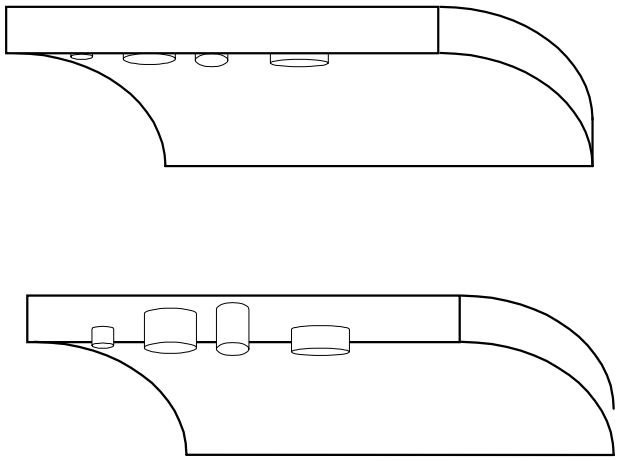

Figure A.1 - Sketch of calibration standard for voids and delaminations

The calibration standard for adhesive bonded joints should be produced using pipe segments with matching stair-step patterns machined into the surfaces. Controlled voids (areas lacking adhesive) may be achieved by not completely coat steps with adhesive (or by including removable strips of e.g. polytetrafluoroethylene, Teflon ®). This type of calibration standard is shown in Figure A.2. Both exterior surfaces and inner, machined surfaces should be representative of the surface roughness achieved during fabrication and shaving of adherents prior to adhesive bonding.

Pipe segments machined so that vertical faces are in contact and horizontal faces are separated by specified bond line thickness. Pipe is then bonded and sectioned, with Ø > 45 degrees. Polytetrafluoroethylene (Teflon ®) (or similar) inserts may be placed on horizontal faces during bonding and withdrawn when sectioned, thus guaranteeing that known defects is precisely and repeatable located. Multiple steps may be selected in order to simulate different pipe diameters with a single calibration standard.

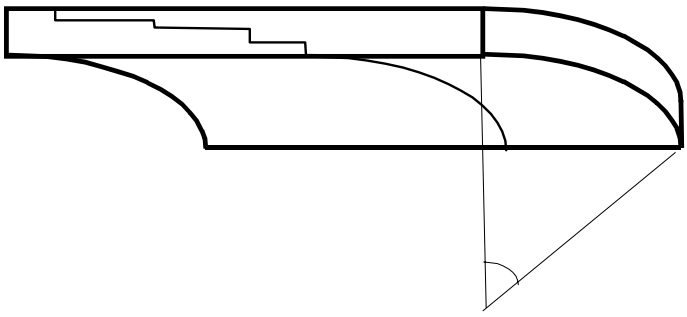

Figure A.2 - Sketch of calibration standard for bonded pipe joints

Each calibration standard shall be labelled with

- pipe manufacturer,
- fitting assembler,
- date of assembly,
- serial number.

A.2.4.2 Calibration

The ultrasonic equipment shall be frequently calibrated as specified by the manufacturer in the operator's manual for the instrument.

A.2.5 Couplant

Water or standard, commercially available ultrasonic couplants may be used for this type of inspection.

A.2.6 Preparations

If an automatic scan covering the entire area being inspected cannot be used, a multi-point inspection template should be used. The template should systematically define the points to be measured. The position of the template should be marked on the test object with permanent ink, to ensure repeatability of the measurements. Indications of orientation, for instance the 12 o'clock position and flow direction, should coincide on the test object and on the template.

A.2.7 Scanning

The number of points tested or scanned shall be sufficient to identify defects larger than the agreed acceptance criteria. Size and position of any observed defects shall be marked on the exterior surface and included in the inspection report.

A.2.8 Reporting

For each inspection, the following information shall be recorded:

- size and position of any observed defects;
- identification and location of the joint inspected;
- name and type of the instrument used;
- probe type and operational frequency;
- identification of the calibration standard used;
- identification of inspection template used;
- name and certification level of operator;
- date and time of the inspection.

However, if no unacceptable defects are detected the following information shall be recorded:

- identification and location of the joint inspected;
- test procedure identification;

- name and type of the instrument used;
- probe type and operational frequency;
- name and certification level of operator;
- date and time of the inspection.

Annex B
(Normative)
Radiographic testing

B.1 Main detectable defects

B.1.1 General

Main detectable defects are

- incorrect wall thickness or fit between male and female adherents,
- some voids, delaminations and lacking adhesive,
- axial misalignment,
- internal excess of adhesive,
- scale build up,
- incorrect insertion of pipes in adhesive sockets.

B.1.2 Limits of detect ability

Radiography (RT) is quite useful for detecting wall thickness variations, water ingress, scale build-up and some voids and areas lacking adhesive.

NOTE This is based on tests performed predominantly in 800 mm outer diameter pipes. Areas of poor adhesion (i.e. “kissing bonds”) will not be detected by this method.

B.1.3 General

RT is not sensitive to surface roughness, but it is sensitive to the orientation of the defect. It is relatively easy to perform onshore, while it is somewhat more complicated on offshore installations due to closing-off of the test areas for unauthorised personnel.

Radiographic test parameters (i.e. tube voltage and exposure time) shall be adjusted compared to steel due to the low density of the polymers and composites. Low to medium tube voltages, typically in the range of 10 keV to 50 keV, is suitable for RT of GRP. RT can be used much as for steel piping once exposure sources and times are changed to match GRP.

From RT results it is possible to determine wall and laminate (i.e. repair) thickness. In some cases it has also been possible to determine the winding angle, and voids or lacking adhesive (particularly, where these become filled with e.g. water). In general, however, it is very difficult to detect lack of adhesive without modifying the adhesive by adding heavy elements, which act as contrast enhancers. ZnI_2, $BaSO_4$, PbO, and W (at 5 weight percent) function well as contrast enhancers, RT can also detect excess adhesive.

B.1.4 Acceptance criteria

B.1.4.1 Lack of adhesive or adhesion

Due to the difference in local stress distributions in a taper/taper and taper/cylindrical joint the acceptance criteria will be different for the two joint types.

The following acceptance criteria shall apply when either voids or poor adhesion is present:

- total defect area shall be < 25 % of total joint area;
- the non-defective axial adhesive length shall be > 50 % of total joint length;
- taper/cylindrical: no defect intersecting the inside edge (nose) of the joint and a defect intersecting the outside edge shall be < 30 % of total joint length (up to 200 mm DN) and < 10 % of total joint length (from 200 mm to 600 mm DN). Largest stresses on the inside of joint.
- taper/taper: no defect intersecting the outside edge of the joint and a defect intersecting the inside edge shall be < 30 % of total joint length. Largest stresses on the outside of joint.

B.1.4.2 Bonded joints

The socket depths shall generally be in accordance with manufacturer's recommendation. A reduction to 80 % of the figures specified by the manufacturer may be acceptable if no voids are visible on the films, see Figure B.1.
With variable socket depth, the lowest measurements shall apply, see Figure B.2.

B.1.4.3 Mechanical couplings

The gap between the pipe ends shall be minimum 20 mm and maximum 50 mm.
The edge of the pipes shall be at least 15 mm from the edge of the film, see Figure B.3.

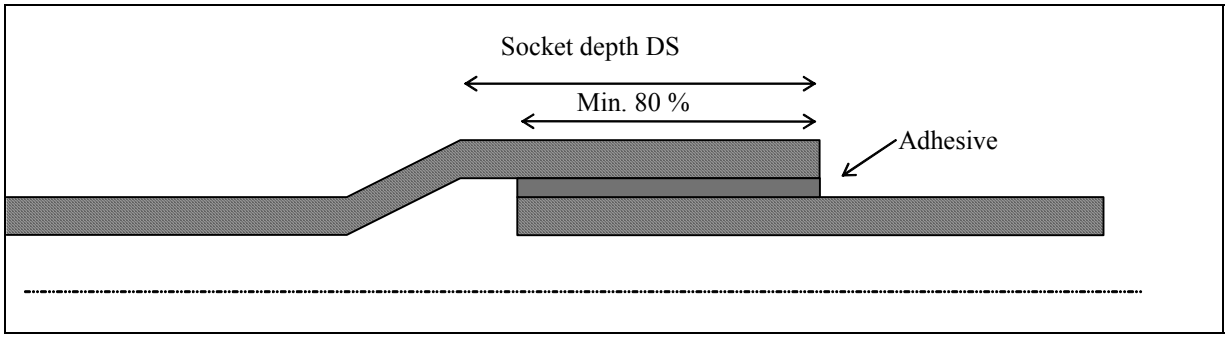

Figure B.1 - The sketch shows acceptable minimum "pipe-into-socket" insertion depth

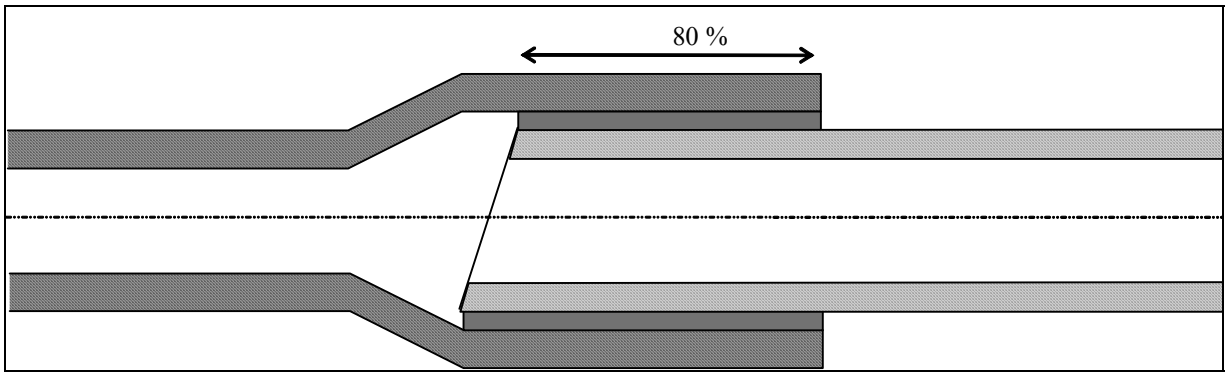

Figure B.2 - The sketch shows minimum insertion length in bonded pipe joint

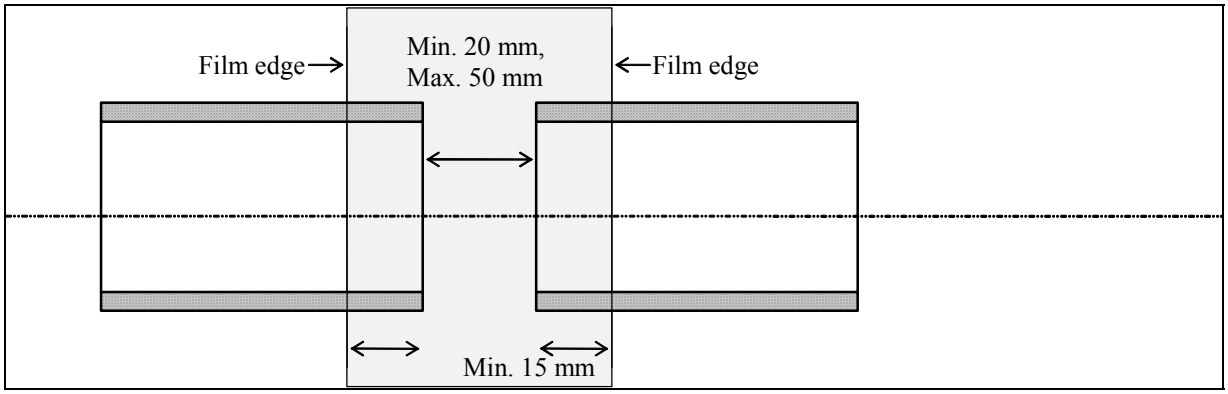

Figure B.3 - The sketch shows location of film for checking position of pipe ends in mechanical couplings

B.2 Procedure for radiographic examination of bonded joints in GRE piping materials and mechcanical couplings

B.2.1 Purpose

The purpose of this procedure is to describe how radiographic examination shall be performed to ensure that optimum film quality/inspection result is achieved.

B.2.2 Personnel qualification

Operators producing radiographs, but do not perform evaluations, shall be qualified to at least EN 473 Level 1 or equivalent.

Operators performing film evaluation shall be qualified to at least Level 2 or equivalent. Those operators shall also have experience with interpretation of radiographs taken of bonded joints in GRP materials.

B.2.3 Equipment

Equipment units to be used are

- Ir 192 with focus 2 x 2 mm with activity less than 25 Ci,
  NOTE Se 75 may also be used in lieu of, or as supplement to, Ir 192,
- Agfa Gevaert D3, D4, D5 (bonded joints) and D7 for mechanical couplings,
- collimator,
- lead numbers and measuring tape for film identification.

B.2.4 Performance

B.2.4.1 Bonded joints

The technique (set-up) to be used is DWSI as described in ASME Boiler and Pressure Vessel Code, Section V, Article 2.

On pipes with outer diameter over 203,2 mm (8 in), film size 30 cm x 40 cm should be used. For smaller pipes film size 10 cm x 24 cm can be used.

Each joint shall have a unique identification number. All films shall be clearly marked with lead numbers (or by flashing) and measuring tape. The marking shall be located on the pipe side. This is to avoid interrupting the area of interest. Where practical, two joints (i.e. muff joints) can be exposed onto one film. The joints have to have different identification numbers. A measuring tape on both joints is not necessary. On pipe with outer diameter less than 152,4 mm (6 in), D3 films and a radioactive source less than 10 Ci to 12 Ci should be used.

B.2.4.2 Mechanical couplings

The technique (set up) to be used is DWSI. The films have to be placed under the bolts (direct contact with the outer surface) and accurately aligned in the centre of the coupling. The film alignment is very important, as the acceptance criteria are dependent on the film being placed in the centre of the coupling. All films shall be clearly marked with lead numbers and measuring tape. As the sensitivity is not critical film type D7 may be used.

B.2.5 Film quality

All films shall be free from developing marks and other irregularities that can interfere with the evaluation of the films.

For bonded joints the density shall be between 2,0 to 3,5. For mechanical couplings the density shall be between 1,5 to 4,0. As no image quality indicator is currently available to verify the sensitivity on GRE bonded joints, it is very important that a fine grain film and a source with lowest activity, as practical, are used.

B.2.6 Film evaluation

All films shall be evaluated in a dark room by use of a suitable viewer.

Voids in the bonding (adhesive layer) appear on the films as darker areas. The defects are easy to detect, as long there is an air gap between the bonded faces.

If the air gap is less than 0,5 mm, voids will be very difficult to detect.

B.2.7 Reporting

For each inspection, the following information shall be recorded:

- size and position of any observed defects;
- identification and location of the joint inspected;
- name and type of equipment/source and film used;
- tube voltage and exposure time;
- name and certification level of operator;
- date and time of the inspection.

However, if no unacceptable defects are detected the following information shall be recorded:

- identification and location of the joint inspected;
- test procedure identification;
- name and type of equipment/source and film used;
- tube voltage and exposure time;
- name and certification level of operator;
- date and time of the inspection.