



BSI Standards Publication

Gas infrastructure - Welding steel pipework - Functional requirements

National foreword

This British Standard is the UK implementation of EN 12732:2021. It supersedes BS EN 12732:2013+A1:2014, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GSE/33, Gas supply.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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European foreword

This document (EN 12732:2021) has been prepared by Technical Committee CEN/TC 234 “Gas infrastructure”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2022, and conflicting national standards shall be withdrawn at the latest by May 2022.

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

This document supersedes EN 12732:2013+A1:2014.

This document has been prepared under a Standardization Request given to CEN by the European Commission and the European Free Trade Association.

Annex L provides details of significant technical changes between this document and the previous edition.

There is a complete suite of functional standards prepared by CEN/TC 234 “Gas infrastructure” to cover all parts from the input of gas to the transmission system up to the inlet connection of the gas appliances, whether for domestic, commercial or industrial purposes.

In preparing this document, a basic understanding of gas infrastructure by the user has been assumed.

Gas infrastructure is complex and the importance on safety of its construction and use has led to the development of very detailed codes of practice and operating manuals in the member countries. These detailed statements embrace recognized standards of gas engineering and the specific requirements imposed by the legal structures of the member countries.

CEN/TC 234 will continue its work updating this standard to the latest developments at regular intervals.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This document contains requirements for the production and testing of weld joints for the installation and modification, including in-service welding, of onshore steel pipelines and pipework used in gas infrastructure. This includes all pressure ranges and processed, non-toxic and non-corrosive natural gas according to EN ISO 13686 and non-conventional gases such as (injected) biomethane and hydrogen, where:

- the pipeline elements are made of unalloyed or low-alloyed carbon steel;
- the pipeline is not located within commercial or industrial premises as integral part of the industrial process on those premises except for any pipelines and facilities delivering gas to such premises;
- the pipework is not located within households or industrial installations according to EN 1775 or EN 15001;
- the design temperature of the system is between $-40\text{ }^{\circ}\text{C}$ up to and including $120\text{ }^{\circ}\text{C}$.

For injected biomethane or hydrogen a detailed technical evaluation of the functional requirements is required, ensuring there are no other constituents or properties of the gases that can affect the integrity of the pipeline.

This document is not applicable to welds produced prior to the publication of this document.

This document specifies common basic principles for gas infrastructure. Users of this document are expected to be aware that there can exist more detailed national standards and/or codes of practice in the CEN member countries.

This document is intended to be applied in association with these national standards and/or codes of practice setting out the above-mentioned basic principles.

In the event of conflicts in terms of more restrictive requirements in national legislation/regulation with the requirements of this document, the national legislation/regulation takes precedence as illustrated in CEN/TR 13737 (all parts).

NOTE CEN/TR 13737 (all parts) contains:

- clarification of relevant legislation/regulations applicable in a country;
- if appropriate, more restrictive national requirements;
- national contact point for the latest information.

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.

EN 1708-1, *Welding - Basic welded joint details in steel - Part 1: Pressurized components*

EN 10204, *Metallic products - Types of inspection documents*

EN ISO 636, *Welding consumables - Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels - Classification (ISO 636)*

EN ISO 2560, *Welding consumables - Covered electrodes for manual metal arc welding of non-alloy and fine grain steels - Classification (ISO 2560)*

EN ISO 3834-2, *Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements (ISO 3834-2)*

EN ISO 5817, *Welding - Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) - Quality levels for imperfections (ISO 5817)*

EN ISO 6520-1, *Welding and allied processes - Classification of geometric imperfections in metallic materials - Part 1: Fusion welding (ISO 6520-1)*

EN ISO 9606-1:2017, *Qualification testing of welders - Fusion welding - Part 1: Steels (ISO 9606-1:2017)*

EN ISO 9692-1, *Welding and allied processes - Types of joint preparation - Part 1: Manual metal arc welding, gas-shielded metal arc welding, gas welding, TIG welding and beam welding of steels (ISO 9692-1)*

EN ISO 9712, *Non-destructive testing - Qualification and certification of NDT personnel (ISO 9712)*

EN ISO 10675-1:2016, *Non-destructive testing of welds - Acceptance levels for radiographic testing - Part 1: Steel, nickel, titanium and their alloys (ISO 10675-1:2016)*

EN ISO 10863:2011, *Non-destructive testing of welds - Ultrasonic testing - Use of time-of-flight diffraction technique (TOFD) (ISO 10863:2011)*

EN ISO 10893-8, *Non-destructive testing of steel tubes - Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections (ISO 10893-8)*

EN ISO 11666, *Non-destructive testing of welds - Ultrasonic testing - Acceptance levels (ISO 11666)*

EN ISO 13588, *Non-destructive testing of welds - Ultrasonic testing - Use of automated phased array technology (ISO 13588)*

EN ISO 14171, *Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels - Classification (ISO 14171)*

EN ISO 14174, *Welding consumables - Fluxes for submerged arc welding and electroslag welding - Classification (ISO 14174)*

EN ISO 14175, *Welding consumables - Gases and gas mixtures for fusion welding and allied processes (ISO 14175)*

EN ISO 14341, *Welding consumables - Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels - Classification (ISO 14341)*

EN ISO 14732:2013, *Welding personnel - Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials (ISO 14732:2013)*

EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure specification - Part 1: Arc welding (ISO 15609-1)*

EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys (ISO 15614-1)*

EN ISO 17636-1, *Non-destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film (ISO 17636-1)*

EN ISO 17636-2, *Non-destructive testing of welds - Radiographic testing - Part 2: X- and gamma-ray techniques with digital detectors (ISO 17636-2)*

EN ISO 17637, *Non-destructive testing of welds - Visual testing of fusion-welded joints (ISO 17637)*

EN ISO 17638, *Non-destructive testing of welds - Magnetic particle testing (ISO 17638)*

EN ISO 17640, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640)*

EN ISO 18275, *Welding consumables - Covered electrodes for manual metal arc welding of high-strength steels - Classification (ISO 18275)*

EN ISO 19285, *Non-destructive testing of welds - Phased array ultrasonic testing (PAUT) - Acceptance levels (ISO 19285)*

EN ISO 20378, *Welding consumables - Rods for gas welding of non-alloy and creep-resisting steels - Classification (ISO 20378)*

EN ISO 23279, *Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds (ISO 23279)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 design pressure

DP

pressure on which design calculations are based

3.2 design temperature

DT

temperature on which the design calculations are based

3.3 round porosity

gas pore in a weld where the length is less as three times the width

3.4 elongated porosity

gas pore in a weld where the length is more than three times the width

3.5**gas**

gaseous fuel which is in a gaseous state at a temperature of 15 °C under atmospheric pressure (1,013 25 bar absolute)

3.6**gas infrastructure**

all pipelines, stations and installations from the input of gas to the transmission system up to the inlet connection of the gas appliances, whether for domestic, commercial or industrial purposes

3.7**gas compressor station**

installation used for:

- transporting gas in pipelines;
- compressing gas from a pipeline to a gas storage facility or vice versa

Note 1 to entry: More than one of the above functions could be performed simultaneously or alternately.

3.8**gas distribution system**

pipeline system including piping above and below ground and all other equipment necessary to deliver the gas to the consumer

3.9**gas transmission**

activity intended to convey gas from one place to another through pipelines in order to deliver gas to distribution systems or to industrial consumers

3.10**hot pass**

second pass for a cellulosic welded pipe girth weld

3.11**installation**

equipment and facilities for the extraction, production, chemical treatment, measurement, control, storage or off-take of the transported gas

3.12**national requirements**

requirements following from applicable national legislation or national standards

3.13**onshore pipeline**

buried and/or above ground pipeline including those sections laid in or across inland lakes or water courses

3.14**pipeline**

system of pipework with all associated equipment and stations up to the point of delivery

Note 1 to entry: This pipework is mainly below ground but also includes above ground parts.

3.15

pipeline components

elements from which a pipeline is constructed. The following are distinct pipeline elements: pipe including cold-formed bends, fittings

Note 1 to entry: Reducers, tees, factory-made elbows and bends, flanges, caps, welding stubs, mechanical joints, fabrications, manufactured from elements referred above.

Note 2 to entry: Manifolds, slug catchers, pig launching/receiving stations, metering and control runs, equipment.

Note 3 to entry: Valves, expansion joints, insulating joints, pressure regulators, pumps, compressors, dedicated pressure vessels.

3.16

pipeline operator

private or public organisation authorised to design, construct, and/or operate and maintain the gas infrastructure, i.e. gas transmission operators (TSO) and gas distribution operators (DSO)

3.17

pipework

assembly of pipes and fittings

3.18

pressure

gauge pressure of the fluid inside the system, measured in static conditions

3.19

root pass

first pass in a single sided pipe girth weld

3.20

station

plant or facility for the operation and/or processing of gas infrastructure

3.21

test pressure

TP

pressure to which a part of the gas infrastructure is subjected to, to ensure safe operation

Note 1 to entry: The test pressure can be different for the different parts of the infrastructure to be tested.

3.22

weld repair

process of repairing a defect that is discovered after the weld has been completed, by additional welding

Note 1 to entry: The repair can involve complete removal of a cylinder of pipe or removal of a localized area by grinding or other means followed by additional welding.

3.23

welder

person who holds and manipulates the electrode holder, welding torch or blow pipe by hand

3.24**weld operator**

person who operates a mechanized welding system

3.25**welding procedure specification****WPS**

document that has been qualified and provides the required variables of the welding procedure to ensure repeatability during production welding

3.26**temper bead method**

weld sequence where the heat-affected zone of the base material is softened as much as possible

3.27**hydrogen dissolved in metal, HDM**

amount in ml of diffusible hydrogen in 100 mg of weld metal

4 General requirements**4.1 General**

Table 1 assigns the application areas to quality requirement categories as a function of the design pressure and pipe materials used.

When using this document the following shall be defined by the pipeline operator, the applicable paragraph is given in brackets:

- a) applicable quality requirement category. (scope);
- b) applicable quality requirements as defined in Table 2 (4.2);
- c) are there specific requirements on visual testing (VT) personnel, and/or qualification (4.2);
- d) applicable welding qualification standards (4.2);
- e) are all weld metal tensile tests required (4.4);
- f) for category B and C, are batch certificates required for welding consumables, when required the pipeline operator has to define the contents of the certificate (4.4.2);
- g) for filler materials not in accordance with listed European standards, is batch qualification with WPQR allowed (4.4.2);
- h) if overmatching weld material is required (4.4.2);
- i) if hot deformation for misalignment compensation is allowed for materials of $R_{t0,5} \leq 360$ MPa (6.2);
- j) is the weld always to be covered after completion of welding (5.9);
- k) for category D, requirements for repair welding procedures (5.10);
- l) extent of NDT techniques (7.2);
- m) choice of acceptance criteria (7.3);

- n) if the data of NDT need to be delivered to the pipeline operator (7.7);
- o) for in-service welds, method, extend and acceptance criteria (D.12).

Additional requirements can be specified when, for example:

- the strain on pipelines and systems;
- the materials;
- the line routing;
- the design or the welding technique;
- local regulations, are considered critical.

Table 1 — Allocation to quality requirement categories

Quality requirement category	Area of activity applies to
B	≤ 5 bar Materials ^a used from group 1.1, 1.2 and 1.4 according to CEN ISO/TR 15608 Yield strength of materials used, $R_{t0,5} \leq 360$ MPa Examples of use: Mains and service pipes in gas distribution systems, pipework in stations
C	> 5 bar ≤ 16 bar Materials ^a used from group 1.1, 1.2 and 1.4 according to CEN ISO/TR 15608 Yield strength of materials used, $R_{t0,5} \leq 360$ MPa Examples of use: Pipelines including pipework in stations and gas distribution systems
D	> 16 bar ^b Materials used from group 1, 2 and 3 according to CEN ISO/TR 15608 Examples of use: Pipelines including pipework in stations and gas transmission systems
Key $R_{t0,5}$ is the specified minimum yield strength according to EN ISO 3183	
NOTE 1 “Category A” for pipework up to and including 100 mbar, as mentioned in the previous version EN 12732:2000, has been incorporated in the pressure range of “Category B” and has been deleted from this table.	
NOTE 2 Gas infrastructure with a MOP up to and including 16 bar is generally dedicated to gas distribution.	
^a When the materials used are outside this range the operator shall review the applicability of the requirements of this standard or apply Quality requirement category D.	
^b Pipelines having hoop stresses at design pressure up to 30 % of specified minimum yield strength ($R_{t0,5}$) and operated at a pressure up to 24 bar can be allocated to quality requirement Category C by the pipeline operator.	

4.2 Quality system requirements

If required by the pipeline operator, a quality system shall be applied to pipeline welding. A set of recommended quality requirements according to EN ISO 3834 (all parts) is provided in Table 2, which specifies the requirements of EN ISO 3834 (all parts) for the different categories as defined in Table 1.

Table 2 — Recommended quality requirements

Requirement relating to:	Quality requirement category in accordance with Table 1		
	B	C	D
Quality system according to: • EN ISO 3834-1 and EN ISO 3834-2 (complete) • EN ISO 3834-1 and EN ISO 3834-3 (standard) • EN ISO 3834-1 and EN ISO 3834-4 (elementary)	+ + •	• • –	• • –
Welding coordination personnel: • Personnel according to EN ISO 14731:2006 • welding engineer • welding technologist • welding specialist • welding practitioner as defined in IIW-IAB-252-07	+ + • •	+ • • +	• +b +b –
NDT^a • Independent NDT company accredited to EN ISO/IEC 17020 or EN ISO/IEC 17025. • personnel performing NDT to EN ISO 9712 • personnel performing Visual Testing; VT level 2, or qualification as welding practitioner or over.	• • +	• • +	• • •
Welding procedure specification (WPS): • According to EN ISO 15609-1 • According to EN ISO 15609-2 (up to 100 mbar)	• •	• –	• –
Approval of welding procedures according to one of the following standards: • EN ISO 15614-1 level 2 (welding procedure test) • EN ISO 15610 (using approved welding consumables) • EN ISO 15611 (previous experience) • EN ISO 15612 (standard welding procedures)^b • EN ISO 15613 (pre-production welding test)	+ • – + +	• – – + +	• – – – +
Key: • recommended + optional – not recommended			
^a testing personal can be employed by either the pipeline operator, the contractor or the NDT company. ^b This can also be applicable in Category D for small projects or for materials with $R_{t0,5} \leq 360$ MPa.			

4.3 Welding contractors

If required by the pipeline operator, contractors shall demonstrate their ability to perform the work. Reference can be made to EN ISO 3834.

4.4 Welding procedure requirements

4.4.1 General

Welding procedures shall be qualified in accordance with the standards as specified by the pipeline operator, for guidance see Table 2 recommended quality requirements. For welding process 311 the maximum design pressure for which this process is allowed is 100 mbar.

The welding procedure specification shall be in accordance with EN ISO 15609-1 and be submitted to the pipeline operator for approval prior to commencement of welding.

4.4.2 Welding consumables

Welding consumables shall be in accordance with:

- EN ISO 2560 and EN ISO 18275 for shielded metal arc welding (process no. 111);
- EN ISO 14341 and EN ISO 636 for gas metal arc welding (process nos. 135, 141);
- EN ISO 17632 for flux-cored arc welding (process nos. 114, 136);
- EN ISO 14175 for shielding gases;
- EN ISO 14171 for submerged arc welding (process no. 12X);
- EN ISO 14174 for fluxes for submerged arc welding (process no. 12X);
- EN ISO 20378 for autogenous welds (process no. 311).

The numbering of the processes given in brackets is in accordance with EN ISO 4063.

If the filler material to be used in production welding is not listed in these European Standards, applicable measures shall be set by pipeline operator.

Batch testing of the filler materials can be required by the pipeline operator. In this case the certificates shall be in accordance with EN 10204, type 3.1. The certificate shall at least contain the chemical composition and the as welded mechanical properties.

For DP over 16 bar

Welding consumables shall be certified minimum as 3.1 according to EN 10204. The chemical composition and mechanical tests as specified in the applicable standard for the welding consumable shall be listed in the certificate.

The use of overmatched consumables is recommended. Weld metal overmatching can be a welding procedure qualification requirement of the pipeline operator, for example when using the EPRG girth defect acceptance criteria (Annex G). Unless otherwise agreed, matching weld metal for girth welds shall be required.

The chemical composition of the deposited weld metal shall be compatible with the base metal, taking into account any specific property requirements.

For wall thicknesses > 8 mm a lower strength consumable can be used for the root and hot pass.

After filler material has been removed from its original package, it shall be protected or stored in accordance with the manufacturer's requirements, so that its characteristics or welding properties are not affected.

4.4.3 Impact testing requirements

For DP over 16 bar

In addition to EN ISO 15614-1, charpy impact testing is required for weld and heat affected zone for a wall thickness of 5 mm and over. When extracting the charpy impact specimens the thickness shall be as large as possible. The test temperature is to be taken at the minimum design temperature of the pipeline, unless otherwise specified by the pipeline operator.

The minimum required values are listed below:

- a) steel grades with specified minimum yield strength less or equal to 360 MPa average: 27 joules (J), individual: 20 J;
- b) steel grades with specified minimum yield strength greater than 360 MPa average: 40 J, individual: 30 J;
- c) if the EPRG weld defect acceptance rules are specified by the pipeline operator see Annex G: average: 40 J, individual: 30 J;
- d) for sub-size specimens the measured energy shall be converted to the full-size impact energy C (in joules) using the formula:

$$C = \frac{8 \text{ mm} \times 10 \text{ mm} \times C_m}{A_m}$$

where

C is the impact energy for the full-size specimen, in joules;

C_m is the measured impact energy, in joules;

A_m is the cross-section measured under the notch, in square millimetres.

If an all-weld-metal tensile test is specified, the test specimen and the tests shall be in accordance with the appropriate European Standard. Yield strength shall be equal to or higher than the specified minimum yield strength of the parent metal.

For welds made in pipes using a lower strength weld consumable in the root and with a deposited weld metal thickness in the qualification test piece of 5 mm or less no separate impact tests are required. When this separate testing, as required by EN ISO 15614-1 is not performed, the PQR has the following limitations:

- the PQR is only used with the same sequence of processes;
- the maximum qualified thickness of the root layer is 1,5 the deposited weld metal thickness of the weld process or filler material used for the root.

4.5 Welders

All welders shall be qualified in accordance with Annex A for the work they are required to undertake.

4.6 Welding supervisory and coordination personnel

If a quality system is required by the pipeline operator, the supervisory and the coordination personnel should be qualified as indicated in Table 2.

Welding tasks and responsibilities for welding shall be clearly assigned to personnel with the appropriate experience and technical knowledge. The supervisory and coordination personnel can be employed by the operator or contractor.

The monitoring of welding work on site can be delegated from the welding coordinator in charge to a welding engineer, welding specialist, welding technologist or a welding practitioner when listed as recommended or optional for the categories as per Table 2.

4.7 Non destructive testing (NDT)

NDT Personnel performing testing in accordance with this document shall be qualified to an appropriate level in accordance with EN ISO 9712 or equivalent in the relevant industrial sector. For direct VT by welding practitioners and over they should be qualified to EN ISO 14731:2006. An independent NDT company should be accredited to EN ISO/IEC 17020 or EN ISO/IEC 17025.

NOTE For digital radiography to EN ISO 17636-2 additional qualification can be required for technique and personnel.

4.8 Destructive testing (DT)

The DT company should be accredited to EN ISO/IEC 17025.

5 Production welding

5.1 General

All welding shall comply with the approved welding procedure specifications.

5.2 Working area

The working space shall enable adequate access to the working area in order to provide a safe environment and to allow satisfactory production and testing of a weld joint. If feasible, working pits or bell holes should be constructed in the pipe trench. They should have a minimum free length of 3,0 m ($\pm 0,1$ m) at the weld area. The distance from pipe to bell hole bottom should be not less than 0,4 m ($\pm 0,1$ m) and from pipe to trench wall not less than 0,6 m ($\pm 0,1$ m).

Bell holes shall be kept free of water during welding and welding related work.

5.3 Layout of weld joints

Weld joints, in particular tie-ins, shall be arranged and designed in a way suited to the planned welding and testing technique. The placement of tie-in welds is particularly important.

5.4 Types of weld joints

5.4.1 General

Unless otherwise agreed, pipes and pipeline fittings shall be connected using butt-welded joints.

5.4.2 Weld fit-up

Weld fit-up shall be sufficient to ensure a good penetration of the joint. In areas subject to ground movements and at unconcealed pipe spans and at pipelines on bridges, changes of direction using segmental cuts are not permitted.

For DP up to and including 16 bar

Segmental cuts up to 7,5° (tangents up to 15°) are permitted for pipelines and systems for quality requirement Category B. Segmental cuts up to 2,5° (tangents up to 5°) are permitted for pipelines and systems in quality requirement Category C.

For DP over 16 bar

Pipes, pipeline parts and other components which require marking shall be re-stamped or remarked next to the cutting line prior to cutting.

The minimum length of a single pipe to be welded into an underground pipeline shall be 0,5 times DN. For pipework at stations smaller lengths can be used provided the conditions of 5.3 are met.

Where forged fittings are used in a tie-in situation, the fittings should have pipe-pups welded to them before welding into the line so that the final tie-in is a pipe-to-pipe joint.

Segmental cuts shall be avoided whenever possible. When segmental cuts are used these shall be limited to 1,5° (tangents up to 3°). When segmental cuts are used, only manual welding shall be allowed.

5.4.3 Different wall thickness

When welding pipework of different wall thicknesses has to be performed, 5.5.1 and/or EN 1708-1 shall apply, this to avoid stress concentration and weld defects.

5.4.4 Laminations

The presence of laminations should be taken into consideration when performing a girth weld. When welding branches, nozzles and structural parts, presence of laminations shall be checked. Additional precautions can be required where welding is performed in the area of laminations. See Table 6 for method and criteria.

5.4.5 Interaction of longitudinal or spiral seams at a girth weld

Unless otherwise agreed, interaction between longitudinal or spiral seams at a girth weld shall be avoided. As a guidance the distance between two longitudinal or spiral seams can be taken as a minimum of 10 times the wall thickness or 100 mm.

5.5 Joint preparation

5.5.1 Joint end preparation

To ensure the required weld quality; all necessary details concerning the joint preparation shall be included in the welding procedure specification. Joint edge preparations shall comply with the appropriate documents, such as EN 1708-1 and EN ISO 9692-1. The choice of joint configuration shall take into account the welding technique, the NDT technique, the welding position and the accessibility of the joint. The welding of alignment aids and similar temporary attachments onto pipelines should be avoided. If necessary, alignment aids and similar temporary attachments can be used with the approval of the pipeline operator. The steel used for these temporary attachments shall be of an appropriate steel grade.

For DP up to and including 5 bar

If approved by the pipeline operator, socket joints according to EN 1708-1 are allowed for all diameters in quality requirement Category B. Bell and spigot, socket or sleeve welds shall be set up so that the root gap of the fillet weld is the smallest possible. No tools with sharp edges shall be used during this process. If the end of the socket shall be forged, it shall be heated to a forging temperature suitable for the material grade.

For DP up to and including 16 bar and over 16 bar

Pipes and pipeline components shall be clamped in such a way that strain due to movement on the weld during welding is avoided.

The welding of alignment aids and similar temporary attachments onto pipelines is not allowed

Absence of laminations shall be proven by ultrasonic testing or other appropriate means, before branches, nozzles and structural parts are welded onto pipelines or other components (see Annex B).

5.5.2 Alignment of the joints

Alignment clamps shall be used where possible to reduce the outside and inside alignment. Type and time of removal of the clamp shall be included in the welding procedure specification.

External and internal(root) misalignment is acceptable as far as it is not affecting the integrity of the joint and is within the acceptance criteria for the weld. For recommendations see Table 3a and Table 3b.

Table 3a — recommended external misalignment of surfaces

Wall thickness (t)	Permissible external misalignment
$\leq 10 \text{ mm}$	$0,3 \times t$
$10 \text{ mm} < t \leq 24 \text{ mm}$	3,0 mm
$t > 24 \text{ mm}$	$0,125 \times t$

Table 3b — recommended internal misalignment of surfaces

Length along the weld	Permissible internal misalignment
Around the full circumference	1 mm
Length equal to DN	2 mm
For a wall thickness over 10 mm for a length of $1/3 \times \text{DN}$	2,5 mm

Root misalignment can be compensated by the use of clamps. Difference in wall thickness can be compensated by grinding, machining or by transition pieces.

If agreed by the pipeline operator, Misalignment of pipes and pipelines made of steel grades with a minimum specified yield strength $R_{t0,5}$ less than or equal to 360 MPa which is outside the tolerance range of the Table 3 can be compensated for by hot deformation. The heat-treatment condition of the material shall be taken into account.

NOTE In some cases, the strength of thermo-mechanically treated as well as quenched and tempered steels is permanently reduced by heating to temperatures above 580 °C.

5.6 Preheating

Preheating shall be applied in accordance with the welding procedure specification.

5.7 Tacking

Whenever tack welds are used, they shall be made using the welding procedure designed for the root pass and they shall be performed by a qualified welder. They shall be distributed equally around the circumference.

The tacks shall be free from cracks. Cracked tacks shall not be welded over, and shall be ground out and re-welded.

5.8 Welding

All welding, including repairs and welding of patches for repair, shall be carried out in accordance with the approved welding specification. Gas welding can be applied for pipes with an operating pressure not over 100 mbar.

Each weld welded in a fixed position on a pipe with a diameter $\geq$ DN 400 shall be welded simultaneously by at least two welders, (one on each side of the girth weld).

Precautions shall be taken to:

- minimize hydrogen pick-up in the work, in particular for steels which are sensitive to cold cracking;
- avoid condensation;
- avoid air movements in the pipe;
- avoid uncontrolled electrical current;
- minimize magnetic effects;
- avoid cold cracking;
- avoid arc strikes.

For DP over 16 bar

During welding, particular attention shall be paid to:

- preheat temperature;
- interpass temperature;
- the number of runs or the actual welded thickness before work can be interrupted;
- the total time for weld completion;
- the welding energy used.

In cases where tie-in welds are not subjected to hydrostatic testing and when welding steel grades from material with yield strength $R_{t0,5}$ over 360 MPa, use of cellulosic electrodes shall be approved by the pipeline operator.

5.9 Actions after welding

After the weld is completed, weld spatter shall be removed. The weld surface shall be cleaned of slag. The cooling process shall not be accelerated beyond the rate specified in the welding procedure specification.

When occurred, arc strikes have to be removed. For materials with $R_{t0,5} > 360$ MPa, MT testing in accordance with Table 6 has to be performed.

Where air temperatures are below 5 °C and/or during poor climatic conditions like wind or rain, or if the pipeline operator requires it, the weld joint shall be protected against excessive rapid cooling.

Stress-relief heat treatment can be necessary.

5.10 Repair of weld defects

Welds joints which do not meet the specified requirements shall be repaired or cut out. On each weld joint which requires repair, the faulty area shall be clearly marked. The marking shall not be removed until the defect has been repaired and the repair work has been inspected. If a defect, which requires repair, exceeds more than 20 % of the total weld length, or if the total length of defects in the weld amount to 20 % of the total weld length, the complete weld joint and the heat affected zone shall be cut out and re-welded, unless otherwise agreed with the pipeline operator.

Weld joints with cracks shall be completely cut out. Repair of cracks is only allowed after approval of the pipeline operator, provided the cause of the crack has been established beyond doubt and proper measures are taken to prevent re-occurrence of a crack.

Repairs shall be retested non-destructively with the same technique as used in the first examination, unless otherwise approved by the pipeline operator. If non-destructive testing of a repair reveals the repaired area still has unacceptable indications, the weld including the heat affected zone shall be cut out and re-welded, unless otherwise agreed with the pipeline operator.

For DP over 16 bar

Repair welding shall be performed in accordance with a qualified welding procedure. The pipeline operator shall specify if the same welding procedure is allowed or if a specific repair welding procedure shall be qualified

5.11 Destructive testing of production welds for DP over 16 bar

The minimum number of production welds to be tested shall be in accordance with Table 4. The destructive tests shall be in accordance with EN ISO 15614-1 and the requirements of the pipeline operator for the welding procedure qualification.

The weld tested shall be representative for all the production welds.

If one of the test results is not acceptable, further investigations, as approved by the pipeline operator, shall be made in order to:

- define the cause of the unacceptable results;
- identify the unacceptable part(s) of the pipeline;
- analyse the consequences of the results.

The pipeline operator shall decide on the acceptance of the pipeline.

Table 4 — Minimum number of production test welds as function of pipeline length

Pipeline length L km	Number of samples
$1 < L \leq 10$	1
$10 < L \leq 50$	2
$L > 50$	2 plus 1 further sample per length of 50 km or part thereof

6 Attachment-, and in-service welding

6.1 General

Before welding procedures, as given below, are carried out, the type and scope of testing of the weld joint shall be specified. The scope of the testing shall be in accordance with 7.2. The testing technique used will depend on the type and dimension of the weld.

6.2 Attachment of structural parts

Structural parts shall be attached using a continuous weld.

When welding structural parts onto components made of steel grades with $R_{t0,5} > 360$ MPa, measures shall be employed which take account of the material characteristics. These precautions shall be specified in the welding procedure specification.

6.3 Attachment of cathodic protection connections

Full details of the joining technique and associated equipment should be submitted to the pipeline operator for approval prior to use and should be in line with the manufacturer's recommendations.

Electrical bonds to the pipe surface shall be made with a welding or brazing method which does not alter the integrity of the metal of the pipe. When the temperature of the pipe metal is exceeding 450 °C during the process it shall be demonstrated by a procedure qualification record that the metallurgical structure is not adversely affected.

The attachments should be located at least 100 mm from any seam or circumferential weld. The weld area should be clean, dry and free from oil, grease, mill scale or other foreign matter. Preheating should be applied as specified in the approved procedure.

Operators shall have their skill tested in to qualify for making cathodic protection connections.

When cable connections are made to the pipeline, the adhesion of the weld shall be verified. The electrical resistance of each joint should be measured and should not exceed 0,1 Ω .

For more detailed information on qualification procedures for operator end methods see Annex K.

6.4 Hot-tapping and other welding work on in-service pipelines

Hot-tap welding shall only be carried out after sufficient research and development to ensure the safety of the operation and the correct mechanical properties of the weld.

Prior to the execution of welding work on in-service pipelines, the pipeline operator shall decide whether the design, the material and the construction condition of the pipeline allow welding under operating pressure. Critical aspects for hot-tap welding shall be included in the welding procedure

specification and shall be subject to approval by the pipeline operator. For more detailed information see Annex D

The longitudinal seam weld of a split attachment shall not be welded or tack welded to the pipe wall of the in-service pipe.

Where the attachments are of steel grades with specified $R_{t0,5} > 360$ MPa or are designed so that longitudinal contraction stresses can cause deformation, the first circumferential fillet weld shall be completed before the second is started.

Where tacks for installation purposes are necessary in the area of the second circumferential weld these shall be ground out completely.

7 Inspection of the weld joint

7.1 General

Weld quality shall be ensured by inspection of the welds using non-destructive testing and/or destructive tests. The results of these tests shall be documented.

7.2 Scope of inspection

The inspection shall comprise inspection during welding, final visual inspection, non-destructive testing and destructive testing.

The minimum extent of non-destructive testing in respect of the quality requirement category and the type/position of the weld joint is given in Table 5.

When less than 100 % of the welds is tested the pipeline operator or his designated nominee shall select which welds are to be tested.

Where less than 100 % non-destructive testing is performed and the quality of the weld joint does not meet the requirements, further welds shall be examined to determine the extent of the problem. The cause of the fault shall be eliminated. Except when otherwise agreed, two further welds shall be inspected for each rejected weld.

Table 5 — Minimum extent of non-destructive testing

Quality requirement category in accordance with Table 1	Type/position of the weld joint	Visual examination by welding supervisor	Volumetric NDT ^a	Surface crack test
B	Circumferential welds	b	b	–
	Branches, nozzles and fillet welds	b	–	b
	Longitudinal seams	100 %	10 %	–
	Unconcealed pipe spans ^g ;	100 %	c	–
C	Circumferential welds	10 %	10 %	–
	Branches, nozzles, fillet welds	100 %	–	10 %
	Longitudinal seams	100 %	100 %	–
	Weld joints not included in the pressure test	100 %	100 %	–
	Unconcealed pipe spans ^g ;	100 %	100 %	–
D	Circumferential welds	100 %	100 %	–
	Branches, nozzles, fillet welds	100 %	f	20 % ^d
	Longitudinal seams, Sweepolets	100 %	100 % ^e	–
	Weld joints not included in the pressure test	100 %	100 % ^e	–
	If pipelines/units are laid or installed in built-up areas	100 %	100 %	–
	Unconcealed pipe spans ^g ;	100 %	100 %	–

^a The proportion of techniques shall be agreed.

^b The extent of NDT depends on the representative random sample on the basis of the total number of weld joints made by a welder during the course of one year.

^c The pipeline operator shall specify the extent of non-destructive testing taking into account the design conditions, for example:

- external loads in addition to internal pressure;
- supports;
- expansion due to temperature;
- earthquake risk.

^d Where welds with incomplete penetration are used, the pipeline operator can require 100 %.

^e Seams shall be tested 100 % by two different inspection techniques, unless the probability of detection for the allowed defect dimensions of the NDT technique used is 90 % or higher.

^f For branches and nozzles, consideration should be given by the pipeline operator to these methods.

^g Pipelines on bridges, pipeline sections crossing railways, major roads and motorways, navigable waterways or landing strips/runways.