Gas Industry Standard

GIS/P2: 2024

Specification for

Welding of Steel Land Pipelines Designed To Operate At Pressures Greater Than 7 Bar (Supplementary to BS 4515-1:2009)

Cadent
Your Gas Network

Gas Networks Ireland

national gas transmission

Northern Gas Networks

SGN

WALES&WEST UTILITIES

Contents

Foreword

Gas Industry Standards (GIS) are revised, when necessary, by the issue of new editions. Users should ensure that they are in possession of the latest edition. Contractors and other users external to Gas Transporters should direct their requests for copies of a GIS to the department or group responsible for the initial issue of their contract documentation.

Comments and queries regarding the technical content of this document should be directed in the first instance to the contract department of the Gas Transporter responsible for the initial issue of their contract documentation.

This standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with this engineering document does not confer immunity from prosecution for breach of statutory or other legal obligations.

Mandatory and non-mandatory requirements

For the purposes of a GIS the following auxiliary verbs have the meanings indicated:

can indicates a physical possibility

may indicates an option that is not mandatory

shall indicates a GIS requirement

should indicates best practice and is the preferred option. If an alternative method is used then a suitable and sufficient risk assessment needs to be completed to show that the alternative method delivers the same, or better, level of protection.

Disclaimer

This engineering document is provided for use by Gas Transporters and such of their contractors as are obliged by the terms of their contracts to comply with this engineering document. Where this engineering document is used by any other party, it is the responsibility of that party to ensure that the engineering document is correctly applied.

Brief History

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1 SCOPE

This specification provides requirements for the welding of steel land pipelines, designed to carry non sour dry natural gas and to operate at pressures greater than 7 bar; in accordance with IGEM/TD/1 in the UK, or IS 328 in the Republic of Ireland.

This specification details the requirements for the welding of carbon, carbon manganese and low alloy steel pipelines with specified minimum yield strengths (SMYS) not exceeding 555 N/mm^2 (i.e., grade L555 or X80).

This specification applies to the welding of pipe, fittings and attachments that comply with the relevant Gas Transporter specifications given in Table 3 of this specification. It also applies to the welding of pipe or fittings, not manufactured in accordance with the specifications in Table 3, providing that the design and the mechanical and chemical properties of the pipe or fitting comply with one of the specifications listed.

Welding shall be in accordance with the parent standard BS 4515-1:2009, except where amended by the additional or alternative requirements contained within this specification. All modifications herein shall take precedence over the parent standard. The main heading references used in this specification correspond to those in the parent standard. New main heading references are suffixed with a letter i.e., A, B, …. New subheadings use a continuation of the numbering in the relevant section. This specification contains appendices which are separate and additional to the Annexes of the parent standard.

2 NORMATIVE REFERENCES

Documents referenced in this specification are listed in Appendix A unless already referenced in Section 2 of BS 4515-1:2009. The latest edition of the referenced documents, including all addenda and revisions, shall apply unless a dated reference is specifically given.

The Gas Transporter specifications referenced by this specification are all listed as GIS documents e.g., GIS/F1. However, at the time of writing it is known that not all documents are available in GIS format. In the intervening period, Gas Transporter internal specifications of the same code shall be utilized until a GIS document becomes available and has been adopted by the relevant Gas Transporter.

3 TERMS AND DEFINITIONS, SYMBOLS, ABBREVIATIONS AND UNITS

3.1 Terms and Definitions

The definitions applying in this Specification that are additional to those given in BS 4515-1 are listed in Appendix B.

3.2 Abbreviations

The following abbreviations are used in this specification:

AUT Automatic ultrasonic testing

CE Carbon equivalent value (also CEV)

CTOD Crack tip opening displacement

DN Nominal diameter

FBE Fusion bonded epoxy

HAZ Heat affected zone

HV Vickers hardness

MPI Magnetic particle inspection (also MT)

NDT Non-destructive testing

OD Outside diameter

PWHT Post weld heat treatment

pWPS Preliminary welding procedure specification

SMYS Specified minimum yield strength

TIG Tungsten inert gas welding (also GTAW)

T/V Transverse direction

WPS Welding procedure specification

3.3 Weld Positions

The notation used for weld positions in this standard is defined in BS EN ISO 6974.

3A QUALITY SYSTEMS

To ensure effective quality control of all stages of the welding process (including as a minimum, planning, design, qualification, execution, inspection, testing, and recording) the manufacturer or contractor shall hold BS EN ISO 3834-2 accreditation. The accrediting test body shall be UKAS certified.

3B HEALTH & SAFETY REQUIREMENTS

All personnel involved with welding shall be suitably qualified and experienced.

The Gas Transporter and Contractor(s) shall comply with relevant health and safety legislation.

Safety precautions include, but are not limited to:

a) Safe assembly, set-up, and turn-off procedures

b) Safe control of welding fumes and gases

Note: Particular attention is drawn to recent changes in HSE guidance reclassifying welding fumes from carbon steel as carcinogenic.

c) Personal protection

d) Fire hazards

e) Welding in confined spaces

f) Awareness of welding environment

g) Environment of increased hazard electric shock

h) Radiation from the arc

i) Effects of stray arcing

j) Safe storage, handling and use of compressed gases

k) Leak detection on gas hoses and fittings

4 INFORMATION AND REQUIREMENTS TO BE APPROVED AND DOCUMENTED

4.1 Information to be Supplied by the Gas Transporter

Table 1 provides Gas Transporter responses to the list of questions presented in Section 4.1 of BS 4515-1.

Table 1. Information Supplied by the Gas Transporter.

	Information (BS 4515-1, Section 4.1)	**Gas Transporter Response**
a)	Whether batch testing of electrodes and filler materials is required (see 7.1).	Batch testing is required when welding steels of minimum specified yield strengths greater than 485 N/mm^2 (L485 or X70 grade).
b)	Whether specific compositional controls are to be applied to the deposited weld metal (see 7.1).	Specific compositional control requirements will be contract specific.
c)	The degree of yield strength overmatching for welds in pipe materials where installation methods involve plastic deformation of the pipe or for welds in grade L555 pipe (see 7.1).	For L555 (or X80) pipe material grade the deposited weld metal yield strength shall overmatch the SMYS of the parent material by at least 5%. Any other additional requirements will be contract specific.
d)	Whether different batches of electrodes and filler materials are to be individually identifiable and completely separated (see 7.2).	All consumables shall be identified by type, classification, and individual batch number.
e)	The type and number of re-tests required in the event of failure (see 8.1 k).	In the event of failure of any of the mechanical tests, retests may be permitted at the Gas Transporter's discretion. (see 8.1 k of this specification).
f)	Whether an alternative location is specified for the excavation location for the repair weld test (see 8.4.1).	Alternative locations are not required.
g)	Whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe reeling (see 8.1i).	Not applicable to land pipelines.
h)	Whether specimens should be allowed to cool for durations other than 24 hours before testing (see 8.1g).	Any alternative duration will be contract specific.
i)	The method of weld tensile testing when a minimum weld metal yield strength requirement is specified (see 8.3.2.3).	All-weld tensile specimens shall be prepared and tested in accordance with BS EN ISO 5178 and BS EN ISO 6892-1.
j)	The number and location of transverse tensile test specimens required for welding procedure testing on pipes up to and including 114.3 mm OD (see 8.3.2.1).	Unless otherwise specified by the Gas Transporter, transverse tensile testing is not required for butt welds in pipe of outside diameter ≤ 114.3 mm OD (see 8.3.2 of this specification).
k)	Whether Charpy impact tests are required for welding procedure approval of butt joints (see 8.3.2.1)	Charpy impact testing is required for all butt welds in pipe/fittings greater than 114.3 mm (see 8.3.2 of this specification).

	Information (BS 4515-1, Section 4.1)	**Gas Transporter Response**
l)	The number and location of test specimens required for Charpy impact tests on pipes of diameter 114.3 mm or less (see 8.3.2.1).	Charpy impact testing is not required for butt welds in pipe of outside diameter 114.3 mm or less (see 8.3.2 of this specification). If required, Gas Transporter may specify Charpy impact testing of butt welds in smaller pipe sizes.
m)	Charpy toughness and test temperature for conditions other than pipe and wall thicknesses up to and including 25 mm, minimum design temperatures not lower than -10°C and pipe grades up to L555 (see 8.3.2.6).	The Gas Transporter will specify any requirements different to those specified in 8.3.2 on a contract specific basis.
n)	Whether additional NDT methods for fillet welds apply (see 8.5.1 b).	No additional methods are required.
o)	Whether alternative hardness values to those given in Table 7 are required (see 8.5.2.4).	The hardness limits for non-sour service are applicable.
p)	Whether a proposed change to a welding procedure or equipment requires re-qualification of the welders (see 9.5 i).	Any change in the welding procedure or equipment which, in the opinion of the Gas Transporter, makes production of a sound weld more difficult will be cause for re-qualification of the welder.
q)	Whether prevailing weather conditions are such that quality of the completed weld would be impaired (see 10.9).	The Gas Transporter will decide, in consultation with the contractor, whether weather conditions are such that work has to cease or whether with adequate weather protection welding can proceed or continue.
r)	The method(s) and frequency of visual inspection and NDT (see 11.1).	Each weld shall be examined visually during production and upon completion to ensure compliance with the approved welding procedure and to detect unacceptable defects. See clause 10.12 and 11.1 of this specification and also GIS/NDT2.
s)	Whether completed welds are to be ground (see 11.1).	Welds may be dressed internally or externally to assist inspection and interpretation. Set-in fittings e.g., sweep-o-lets shall have the weld cap and root dressed (internally only where access permits, see 10.1 of this specification).
t)	Whether alternative techniques are to be used for radiographic testing of welded butt joints (see 11.4.1).	An alternative technique to BS EN ISO 17636-1 Class B shall not be used without the approval of the Gas Transporter.
u)	Ultrasonic testing acceptance criteria (see 11.5.3).	BS 4515-1 Table 9, as amended by clause 12 of this specification.
v)	Whether NDT acceptance criteria are to be based on quality control or engineering critical assessment (see 12.1.1).	An ECA will only be required when specified by the Gas Transporter.
w)	Whether the maximum planar defect dimension is to be less than 25 mm (see 12.1.2).	When specified by the Gas Transporter.

	Information (BS 4515-1, Section 4.1)	Gas Transporter Response
x)	Whether a more stringent limit for root penetration is required (see Table 9 flaw type c).	When specified by the Gas Transporter.
y)	Whether different hardness limits for anode bonding joints are required (see B.2).	Different hardness limits are not required
Note: Items (z) to (jj) in BS 4515-1 refer to clad steels which are outside the scope of GIS/P2.		

4.2 Items Subject to Approval by the Gas Transporter

Table 2 provides Gas Transporter responses to the list of questions presented in Section 4.2 of BS 4515-1.

Table 2. Items Subject to Approval by the Gas Transporter.

	Item (BS 4515-1, Section 4.2)	Gas Transporter Requirement
a)	Welding consumables to be used (see 7.1).	Only welding consumables approved by the Gas Transporter may be used. Cellulosic-covered electrodes shall not be used for the welding of fittings of 762 mm outside diameter and above, or on pipes and fittings having a CE Value in excess of 0.43 %. For L555 (or X80) grade pipe materials cellulosic electrodes may only be used for the root and hot pass runs. All subsequent runs shall be completed using low hydrogen welding consumables. All fillet welds shall be welded with low hydrogen electrodes/processes only.
b)	The definition of a batch when batch testing of electrodes and filler materials is required (see 7.1)	For consumables designed to match or exceed the strength of L555 (or X80) grade pipe material, each material cast shall be tested. A BS EN 10204 Type 3.1 certificate, giving the chemical analysis, tensile and Charpy impact properties shall be supplied (see Table 2 a of this specification).
c)	The tensile strength of weld metals for joints between dissimilar materials if other than that of the higher strength parent metal (see 7.1)	The tensile strength of the higher strength parent material shall apply. For L555 (or X80) grade pipe material, the weld metal yield strength shall exceed the parent material minimum yield strength by at least 5%. Excessive overmatching of strength shall be avoided.
d)	Test weld production on pipes shorter than full length (see 8.1 b).	The Gas Transporter will decide whether any deviation can be permitted (e.g., qualification in PC welding position).
e)	Use of roll welding (see 8.1 d).	To be approved by the Gas Transporter. Roll welding shall be limited to pipe of maximum outside diameter 219.3 mm.

	Item (BS 4515-1, Section 4.2)	**Gas Transporter Requirement**
f)	Use of a test weld for destructive testing or re-welding to the same procedure following NDT failure (see 8.1 h).	The Gas Transporter will decide whether a defective test weld may be used for destructive testing. If the failure is due to cracking, the reason for cracking shall be established by the contactor. The results of this investigation shall be submitted to the Gas Transporter before attempting to produce another test weld using the original welding procedure.
g)	The type and number of re-tests of a welding procedure when they are permitted (see 8.1 k)	In the event of failure of any of the mechanical tests, retests may be permitted at the Gas Transporter's discretion (see 8.1 k of this specification).
h)	Welding procedure qualification test details and welding procedure specification for production welding (see 8.1 l).	To be approved by the Gas Transporter prior to production welding commencing.
i)	Any deviations from the ranges given in Table 2 of BS 4515-1.	The limits shall apply separately to pipe and fittings. The Gas Transporter shall review any proposed deviation.
j)	Simulation of a fillet weld joint using flat plate fillet welds (see 9.4.1b).	Simulation plate fillet welds are permitted.
k)	Alternative methods of NDT for welder test pieces (see 9.6c).	With the prior approval of the Gas Transporter, butt weld tests may be examined using manual phased array ultrasonic testing.
		Fillet weld tests shall be examined visually and by magnetic particle inspection.
l)	Giving a welder a second opportunity to gain approval (see 9.8).	The Gas Transporter may agree to a second test attempt, where it can be demonstrated that the reason for failure was beyond the welder's control.
m)	All documentation relating to welder qualification tests (see 9.9)	Records must be kept for the period of validity. A welder's qualification will remain valid for the period stated in BS 4515-1 section 9.1, subject to satisfactory performance.
n)	Use of manual thermal cutting for pipe end bevelling and the ability of the operator (see 10.2).	Not permitted.
o)	The blending out by grinding of minor imperfections within the joint preparation area (see 10.2 a).	The blending out of minor imperfections will be at the Gas Transporter's discretion in each case.

	Item (BS 4515-1, Section 4.2)	**Gas Transporter Requirement**
p)	Method of marking datum points on a joint for ultrasonic testing (see 10.2).	See GIS/NDT2 clause D7.1.
q)	Method of obtaining minimum mis-alignment other than rotation of the pipes (see 10.4).	The contactor shall submit a method statement for approval by the Gas Transporter that details how excessive pipe misalignment will be corrected. (see 10.4 of this specification).
r)	Method of alignment of pipes other than internal line-up clamps (see 10.5.1).	Wherever practicable, approved external or internal pipe clamps shall be used (subject to pipe diameter).
s)	The stage at which line clamps are removed (see 10.5.1).	See BS 4515-1, clause 10.5.1.
t)	The stage at which the pipe is lowered onto skids or support is removed for fittings (see 10.5.2).	The root bead shall be completed and any additional reinforcement deposited (if required by the qualified welding procedure) before the pipe is lowered off. All pipe and fittings shall be fully supported throughout the welding cycle (see 10.5.2 of this specification).
u)	Repair of places where stray arcs have occurred (see 10.8).	See clause 10.8 of this specification.
v)	Means of applying preheat (see 10.10.2).	To be approved by the Gas Transporter prior to use (see 10.10.2 of this specification).
w)	Methods of attaching and removing thermocouples (see 10.10.4).	The methods to be used shall be submitted to the Gas Transporter for approval prior to use.
x)	The welding procedure for branch connections where the angle between the main and branch is less than 60º (see 10.11.1).	All branches shall be made with specialised fittings e.g., forged or pressed tees, forged set-in or set-on fittings which preclude the need for a branch/main angle of less than 60°.
y)	Written ultrasonic examination procedure for pipe material around planned cut out (see 10.11.3).	See GIS/NDT2. A written procedure shall be submitted to the Gas Transporter for approval prior to commencing.
z)	All NDT procedures to be used for inspection and testing (see 11.1).	See GIS/NDT2.
aa)	All inspection personnel (See 11.2).	All inspection personnel shall be qualified in the appropriate grade of the BGAS/CSWIP welding inspection approval scheme, or alternatively the PCN scheme for the NDT duties they are to perform. See GIS/NDT2.

	Item (BS 4515-1, Section 4.2)	**Gas Transporter Requirement**
bb)	The technique in BS EN ISO 17636-1 (formerly BS EN 1435:1997+A2) to be used for radiographic examination (see 11.4.1).	Alternative techniques shall not be used without the Gas Transporter's approval. See GIS/NDT2.
cc)	Any method for magnetic particle testing to be used at above ambient temperature (see 11.7 a).	Magnetic particle testing shall be carried out at ambient temperature, unless otherwise agreed by the Gas Transporter. See GIS/NDT2.
dd)	Any alternative standard to be used for engineering critical assessment (see 12.1.3).	To be specified by the Gas Transporter on a project specific basis (see 12.1.3 of this specification).
ee)	Any proposal to repair a weld (see 12.2.1).	See clauses 8.4 and 12.2 of BS 4515-1 and 8.4 and 12.2 of this specification.
ff)	Any alternative limits on repair weld length (see 12.2.1).	Not permitted without the Gas Transporter's approval.
gg)	Use of root sealing or single run repair deposits (see 12.2.4).	Root sealing and single stringer bead cap repair deposits are not permitted (see clause 8.1.1 (9) and 8.1.1 (10) of this specification).
hh)	More than one attempt at repair (see 12.2.4).	Not permitted.
ii)	The position of the longitudinal seam weld (if applicable) on the subsea pipeline at the hyperbaric weld location (see annex A).	Not applicable. Should Gas Transporter build an underwater pipeline, a specific Annex A supplement to this specification will be issued.
jj)	Joining technique and equipment for brazing or aluminothermic welding of anode bonding leads (see B.1).	To be approved by the Gas Transporter prior to production welding commencing (see clause 8.1 of this specification).
kk)	Proposed brazing or aluminothermic welding procedure specification (see B.2).	To be approved by the Gas Transporter prior to production welding commencing (see clause 8.1 of this specification).
Note: Items ll) to qq) in BS 4515-1 refer to clad steels which are outside the scope of this specification		

5 EQUIPMENT

In addition to the requirements of BS 4515-1:

The Contractor shall provide calibrated arc monitoring equipment that is independent of the welding plant. It shall be used to record welding process or procedure qualification parameters and for the surveillance of production welding. The equipment shall be made available to the Gas Transporter's Inspector for monitoring purposes when requested.

6 WELDING PROCESS

In addition to BS 4515-1 the following requirements shall apply:

6.1 Welding Process and Welding System Approval

When required by the Gas Transporter, the contractor shall demonstrate that any proposed welding process, combined welding process, or welding system has the technical capability to consistently produce sound welds with the desired metallurgical properties using the approved welding procedure. Welding procedure qualification and additional test welds shall be made to prove consistency.

The extent of any welding process or welding system consistency trials must be agreed between the contractor and the Gas Transporter. This should be agreed at tender or contract award and in all cases shall be prior to the welding of procedure qualification welds.

As a minimum, the consistency trials shall include sufficient test welds to qualify the proposed welding procedure, followed by five consistency test welds made using the approved welding procedure.

6.2 Non-Destructive Testing and Destructive Testing Requirements for Welding Process and Welding System Consistency Trials

All consistency test welds shall be subject to full non-destructive testing in accordance with GIS/NDT2, and shall meet the requirements of BS 4515-1, Table 9 (as amended by clause 12 of this specification).

All welding procedure qualification test welds shall be subject to the destructive tests specified in BS 4515-1 and any additional tests required by the Gas Transporter. The number of CTOD test specimens (if required), shall be specified by the Gas Transporter or be agreed between the Gas Transporter and the contractor prior to welding commencing.

One of the five consistency welds (chosen at random by the Gas Transporter) shall be subject to full destructive testing. The extent of CTOD testing for this weld may be varied by agreement between the Gas Transporter and the contractor prior to welding commencing. The test welds shall fully meet the specified acceptance criteria.

Where a gas or self-shielded flux cored wire process is proposed (either individually or as part of a combined process procedure), all five consistency test welds shall be subject to destructive testing. The extent of mechanical testing shall be agreed between the Gas Transporter and the contractor prior to welding commencing.

6A MATERIALS

This specification applies to the welding of pipe, fittings and attachments that comply with the relevant Gas Transporter specifications given in Table 3 of this specification. It also applies to the welding of pipe or fittings, not manufactured in accordance with the specifications in Table 3, providing that the design and the mechanical and chemical properties of the pipe or fitting comply with one of the specifications listed.

Table 3. Material Specifications

Items to be Welded	Relevant Specification(s)
Pipe	T/SP/PIP1 GIS/L3 TS-C4Gas-PIP0 v4.0 (legacy)
Flanges (Weld neck)	GIS/F1
Set-on forged fittings	
Set-in forged fittings (sweepolets)	
Bends	GIS/B12
Tees	
Concentric reducers	
End caps	
Induction bends	GIS/B11

The compositional limits on range of qualification of weld procedures shall be as per of Table 2 of BS 4515-1. The limits shall apply separately to pipe and fittings. The Gas Transporter will review any proposed deviation to assess the potential for any adverse effect on the integrity of the welded joint.

7 WELDING CONSUMABLES (ELECTRODES, FILLER MATERIALS AND SHIELDING GASES)

In addition to BS 4515-1 the following requirements shall apply:

7.1 General

When tested in accordance with clause 8.3.2 the weld metal yield strength of welds in pipe material of L555 (or X80) grade shall overmatch the specified minimum yield strength by at least 5%.

In addition to the requirements of clause 7.1, Note 2 of BS 4515-1, add to the end of the first sentence “and BS EN ISO 18276”.

Welding electrodes and filler metals shall conform to the classification standards listed in Table 4.

Welding electrodes and filler metals shall be supplied with batch certificates in accordance with BS EN 10204. Unless otherwise specified, the chemical composition recorded shall be batch specific (i.e., Type 3.1) and the mechanical properties may be typical values (i.e., Type 2.2).

Table 4. Welding Consumable Classification Standards.

	Welding Process	Consumable Classification Standards
111	Manual metal arc welding	BS EN ISO 2560 System A BS EN ISO 18275
131 135	Metal inert gas welding Metal active gas welding	BS EN ISO 14341 System A BS EN ISO 16834
136 138	Tubular cored metal arc welding, active gas Metal cored metal arc welding, active gas	BS EN ISO 17632 BS EN ISO 18276
141	Tungsten inert gas welding	BS EN ISO 636
121 125	Submerged arc welding (solid wire) Submerged arc welding (tubular cored wire)	BS EN ISO 14171 BS EN ISO 26304

7.2 Storage and Handling

In addition to the requirements of BS 4515-1:

a) The contractor shall produce a welding consumable storage and handling procedure for approval by the Gas Transporter prior to mobilising to site.

b) At the discretion of the Gas Transporter, the contractor may be required to perform such additional tests that demonstrate that the storage and handling of welding consumables has not led to any deterioration of the required consumable specification or properties.

7.3 Shielding Gases

7.3.1 General

Shielding gases used shall be in accordance with BS EN ISO 14175.

The gases or gas mixtures used shall be qualified during weld procedure qualification testing. Any change to the gas or gas mixture group, as defined in BS EN ISO 14175, shall require requalification of the weld

procedure.

7.3.2 Storage and Handling

Where there is a requirement for mixed gases to produce field welds, the gas mixtures shall be provided in proprietary pre-mixed bottles supplied by the gas manufacturer and shall not be mixed in the field.

Compressed gases shall only be stored and handled in accordance with industry guidelines and best practice. Gases that are of questionable purity/quality and those in containers which show signs of damage must not be used. Damaged gas containers must be dealt with in accordance with the manufacturer's recommendations or in the case of an emergency, in accordance with the relevant the Company contingency plans.

8 TESTING, QUALIFICATION AND APPROVAL OF WELDING PROCEDURES

In addition to 8.1 of BS 4515-1, the following requirements shall apply.

8.1 General

Separate procedures shall be provided for any proposed remedial welding. The qualification of remedial welding procedures shall simulate the intended production application. All instances of remedial welding undertaken during production welding shall be recorded.

8.1 k) Replace existing BS 4515-1 clause 8.1 k) with:

In the event of the failure of a specified mechanical test specimen the Gas Transporter shall be informed and the reason for the original failure shall be established and reported by the contractor. Where there is insufficient material available for a re-test, an additional weld will need to be produced for this purpose using the same welding procedure.

If the test failure is due to a geometric or volumetric weld imperfection (i.e., invalid test) a further two specimens shall be tested, or where three individual specimens comprise a set, an additional set of three individual specimens shall be tested.

For failures associated with valid tests, a re-test will not be allowed if more than one of the original specimens tested fails to meet the test requirement.

The concessions and requirements for specific specimen types are given as follows:

Tensile Test Failure

Re-testing for weld tensile tests requires two additional specimens taken from a location either side of the failed specimen. Both re-test specimens shall meet the original test requirements.

Charpy Impact Test Failure

Re-testing for Charpy impact tests requires one set of three additional specimens. Each additional specimen shall meet the individual minimum value required and the combined average value of all six specimens tested (the additional set and the original set) shall meet the required minimum average value for a set.

Hardness Test Failure

Re-testing for hardness test failure requires an additional hardness survey. If only a single hardness impression fails to meet test requirements, two additional hardness impressions, one either side of the original failed impression may be tested. The additional hardness impressions shall not be influenced by deformation caused by the failed impression. Should it be impractical to re-test adjacent to the original failed hardness impression, the original macro specimen surface shall be re-ground (or with the approval of the Gas Transporter the specimen reversed), re-prepared in accordance with 8.3.2.4 and re-tested.

Note: Refer to Table 2 in BS EN ISO 9015-1 for recommendations on minimum spacing distances of hardness indents.

Macro Examination Failure

Re-testing is permitted at the discretion of the Gas Transporter. If permitted, two additional macro-sections shall be taken for macro examination.

Fillet Weld Fracture Test Failure

Re-testing is not permitted.

All re-test results shall be reported to the Gas Transporter who will determine if the welding procedure can be approved, or whether complete re-qualification of the welding procedure is required. The proposed welding procedure will be rejected if any of the additional test specimens fail to comply with the relevant requirements.

8.1 l) In addition to the requirements of BS 4515-1:

A calibrated welding arc monitor that provides a printed record shall be used to record the welding parameters of all welding procedure qualification test welds.

Note: Guidance on measurement of arc energy and calibration of measurement equipment can be found in PD ISO/TR 18491 and BS EN ISO 10012.

8.1.1 Welding Procedure Test Welds (All Welding Processes)

In addition to BS 4515-1 the following requirements shall apply:

1. New welding procedure qualification tests shall be carried out on pipe or fittings made from the same material and of the same outside diameter and thickness as that to be used in production. When approved by the Gas Transporter, the range of approval specified in clause 8.2 of BS 4515-1 may be applied to qualified welding procedures.

2. A minimum of two welders shall be used to weld pipe and fittings with an outside diameter greater than or equal to 406.4 mm.

3. Minimum preheat and weld inter-pass temperatures used in the qualification of a welding procedure test weld shall be in accordance with 10.10.2 of this specification.

4. Welding electrodes or consumables achieving the low hydrogen requirements of Scale D (as defined by BS EN 1011: Part 2, with ≤ 5 ml of diffusible hydrogen content per 100g of deposited weld metal) shall be used to weld all un-pupped fittings ≥ 762 mm outside diameter (see 10.1 of this specification).

5. The sequence of joint completion shall be agreed between the Gas Transporter and the contractor prior to welding procedure qualification tests commencing.

6. Where production conditions are such that pipe-to-pipe joints cannot be completed in one welding heat cycle, the welding of the test welds shall simulate the number of heat cycles where the joint has been allowed to cool to ambient temperature before completion.

7. All fittings shall be welded with a root welded in the vertical-up direction and the weld completed in a single heat cycle. At the discretion of the Gas Transporter, for material grades up to and including L450, induction bends with tangent lengths either side of the bend may be welded in two heat cycles. Induction bends of L555 or X80 grade material shall be welded in one heat cycle.

8. When the qualified welding procedure is intended to cover a range of thicknesses, which during production welding could result in the cap being completed with a split or multi run cap in some instances and a single weave cap in others, the welding procedure qualification test shall cover both capping options and include macro/hardness testing. This may require a further test weld to be produced.

9. Single stringer bead cap repair deposits and single pass internal repair procedures shall not be permitted except as in (10) below.

10. Qualification of a single pass root bead remedial procedure is permitted only for mechanised welding systems using internal welding heads.

11. Remedial welding procedures shall be subject to the same qualification and testing requirements as

repair procedures.

12. Repair welds comprising two weld passes only, that are carried out to the internal surface of the original weld joint and that use the same welding process as the original welding procedure, are required to be qualified by macro and hardness testing only (see 8.4.3.3 and 8.4.3.4 of BS 4515-1). The test specimens shall be removed from the applicable location shown in BS 4515-1 Figure 4b.

13. Re-repairs, i.e., multiple attempts to repair the same area of a weld, shall not be permitted.

14. All fillet welds shall be welded using a low hydrogen process. The procedure shall provide for a minimum of two passes. The major portion of the first pass shall be deposited preferentially on the pipe or major component body.

15. Pin brazing of attachment lugs shall not be permitted for new construction projects.

16. Welding of socket joints shall be completed in a single heat cycle, with care being taken to prevent overheating of the pipe and fitting during welding.

17. Horizontal socket joints shall only be welded using the vertical-up technique (position PH).

18. Socket fillet weld leg lengths shall be equal. The weld profile shall not be concave, and unless otherwise stated, the minimum leg length shall be 1.4 times the pipe nominal thickness.

19. The contractor shall produce sufficient test welds as required to accommodate the specified mechanical testing for each welding procedure qualification.

20. The contractor shall produce a method statement covering the various grinding operations that may be undertaken during pipeline construction.

21. When ultrasonic testing is applied as the primary inspection method to welds made with cellulosic electrodes the weld procedure qualification test shall simulate the cooling effect if water is used as the ultrasonic couplant and the temperature exceeds 60°C at the time of inspection.

8.1.2 Welding Procedure Test Welds (Semi-Automatic or Mechanised Welding Systems)

The optimum welding parameters used to qualify a semi-automatic or mechanised welding system shall be recorded on the WPQR. Should the proposed limits of the welding parameter range need to be more tightly controlled than the tolerances given in BS 4515-1 Table 1, this shall be specified on the WPS sheet.

If the proposed limits of the welding parameter range will exceed the tolerances given in BS 4515-1 Table 1, further qualification will be required. The limits of the ranges used for production welding shall be agreed between the Gas Transporter and the contractor prior to welding commencing.

A test weld shall also be produced that demonstrates that the welding system is capable of producing a sound weld at the extremes of joint fit-up tolerances.

8.1.3 Previously Qualified Welding Procedures

Where a contractor proposes the use of a previously qualified welding procedure, it shall satisfy the essential variable restrictions affecting approval given in clause 8.2 of BS 4515-1 as amended by this specification, and it shall be offered for the Gas Transporter's consideration at the contract award stage. The approval for use of a previously qualified welding procedure will be on a project specific basis and will be at the sole discretion of the Gas Transporter.

Previously qualified welding procedures will not be considered where either of the pipe/fitting materials joined is L555 or X80 grade.

8.1.4 Retrospective Weld Procedure Qualification Testing

When retrospective weld procedure qualification testing is required by the Gas Transporter, this shall be carried out taking account of the following criteria:

a) The same [pipe] materials as used in production.

b) The same WPS as used in production.

c) The same welders which made the production weld(s).

d) The same welding consumable batches (as far as possible).

e) The same work phase and work location as the production weld(s).

This test shall be undertaken as soon as the existing pipe material becomes available. Every effort shall be made to successfully complete the retrospective WPQT prior to commissioning the pipework system. The test weld shall be fully tested in accordance with this specification and shall meet the requirements of this specification.

8.2 Changes Affecting Qualification and Approval (Essential Variables)

In addition to the requirements of BS 4515-1, add the following clauses.

8.2.1 Base Material Specification

When a welding procedure will be used on existing pipe material, confirmation of the pipe chemical analysis and estimated material grade is required. This may be confirmed through the production of the original mill certificate or by material sampling in accordance with an approved procedure, such as GIS/Q10.

L555 (or X80) grade pipe material is supplied to specific manufacturers target chemistry. Where the Gas Transporter identifies a significant change in the target chemistry of individual pipe production runs, then additional welding procedure qualification shall be required.

8.2.2 Set-On Branch Fittings

The diameter range of approval for set-on branch fittings shall be as given in Table 5 and Table 6.

The range of approval for carrier pipe wall thickness shall be 0.7 – 1.5 t.

The range of approval for the welding position is ± 25° of the position tested except for position PC, which is qualified by position PE, PF, or PG.

Table 5. Range of Approval for Set-On Fitting Diameter.

Diameter of Set-on Fitting Tested, D	Range of Approval
33.4 mm	0.5D to 2D
60.3 mm	0.5D to 1.6D
88.9 mm	0.5D to D

Table 6. Range of Approval for Carrier Pipe Diameter.

Diameter of Carrier Pipe Tested, D	Range of Approval
≤ 323.9 mm	0.5D to 2D
> 323.9 mm	> 0.5D

8.3 Testing of Butt Joints For Procedure Qualification

8.3.1 Non-Destructive Testing

The test pieces shall be examined as stated in clause 8.3.1 of BS 4515-1. However, the examination techniques used shall be in accordance with GIS/NDT2.

8.3.2 Destructive Testing

In addition to the requirements of BS 4515-1:

8.3.2.1 Test Specimens

The macro specimens detailed in Figure 1a and 1b of BS 4515-1 shall be hardness tested in accordance with 8.3.2.5.

The number of hardness surveys required for non-sour service by Table 3 of BS 4515-1 shall be amended to two for pipe diameters less than or equal to 114.3 mm, and three for pipe diameters greater than 114.3 mm.

The number of test specimens for destructive testing of repair test welds, where the welding process or procedure is not identical to the mechanised or semi mechanised welding procedure used to make the original joint, shall be as specified in Table 8 of this specification.

8.3.2.2 Transverse Weld Tensile Testing

Transverse tensile testing is not required for butt welds in pipe sizes less than or equal to 114.3 mm outside diameter.

8.3.2.3 Weld Metal Tensile Testing

Where L555 (or X80) pipe material grade is used or where CTOD tests are specified by the Gas Transporter, two all-weld tensile specimens shall be prepared and tested in accordance with BS EN 876 and BS EN 10002 Pt 1. The yield strength obtained for the weld metal shall overmatch the specified minimum yield strength of the L555 (or X80) pipe by at least 5%.

8.3.2.4 Macro-Examination

In addition to the requirements of BS4515-1:

Photographs of each macro specimen showing the location of the hardness impressions shall be provided with the mechanical test records for all welding procedures tested.

BS4515-1 requires that macro test specimens shall be examined at a magnification of x5. In addition, the degree of photographic magnification used shall be recorded accurately on the test report, ideally with a scale marker in the photograph.

Where L555 (or X80) grade material is examined, a macro specimen shall be removed at the intersection of

the pipe seam weld and girth weld location for hardness testing in accordance with 8.3.2.5 of BS 4515-1 and this specification. Where there are two seam welds junctions, the specimen shall be removed from the side of the joint with the highest carbon equivalent percentage.

8.3.2.5 Hardness

In addition to the requirements of BS 4515-1:

Hardness surveys shall be carried out on all macro specimens.

8.3.2.6 Impact Testing

In addition to the requirements of BS 4515-1:

a) Charpy impact testing is required for all butt welds in pipe/fittings 168.3 mm outside diameter and greater. If required, Gas Transporter may specify Charpy impact testing of butt welds in smaller pipe sizes.

b) Unless otherwise indicated, the test temperature shall be:

- 0°C for buried pipelines, or
- Minus 10°C for pipework for use in outdoor ambient conditions, or
- The actual gas temperature, whichever is the lesser.

c) Absorbed energy requirements for Charpy impact tests are given in Table 7 of this specification.

d) For joints greater than 15.9 mm nominal wall thickness, where the welding procedure includes a combination of welding directions and/or combined welding processes, an additional set of weld metal (VWT0) and fusion line (VHT0) Charpy impact specimens shall be taken from within 1 – 2 mm of the outer surface of the pipe and tested. This does not include a composite (aka 'dollymix') procedure where the root pass is welded vertical-up and the remainder of the passes are welded in the vertical-down direction.

When the majority of welding is in the vertical up direction the specimens shall be taken from the 3 o'clock position.

When the majority of welding is in the vertical down direction the specimens shall be taken from the 6 o'clock position.

When the volume of weld deposited in different directions is approximately equal, the location of testing shall be agreed between the Gas Transporter and the contractor prior to welding commencing.

e) When the Gas Transporter specifies that batch testing of welding consumables is required (e.g., for the welding of L555 (or X80) grade material), one set of weld metal, and one set of HAZ, cap Charpy impact specimens (positioned in accordance with BS 4515-1 Figure 3b) shall be taken from the approximate location shown in Figure 1 of this specification and tested at –20°C. These tests are for information purposes only and the need for these tests shall be agreed with the Gas Transporter prior to commencing procedure qualification welding.

Table 7. Charpy Impact Test Requirements.

Pipe Thickness	Charpy V-Notch Specimen Size	Minimum Energy Requirement (J)	
		Individual	Average
≥ 12.5 to < 25 mm	10 x 10 mm	30	40

≥ 12.5 to < 28 mm	10 x 10 mm	45 (c)	56 (c)
≥ 10 to < 12.5 mm	10 x 7.5 mm	24	32
≥ 6.3 to < 10 mm	10 x 5.0 mm	21	28
< 6.3 mm	10 x 2.5 mm	11	15

Notes:

a) For pipe thickness ≥ 12.5 mm full size specimens shall be used

b) The dimensions of sub-sized specimens shall be the largest size specimen possible that can be taken from the available pipe section.

c) Requirement for L555 (or X80) grade materials only.

d) The sub-sized specimen impact requirements apply only to materials with SMYS ≤ 448 N/mm^2.

8.3.2.7 Material Toughness Testing for Fracture Mechanics Calculations

In addition to the requirements of BS 4515-1, add the following clauses:

The Gas Transporter may require additional destructive tests (i.e., CTOD and All-weld tensile tests). They may be specified for particular projects, welding processes or welding systems, where one or both of the pipe materials joined are a L555 (or X80) grade, or where the use of an Engineering Critical Assessment (ECA) to determine defect acceptance criteria is proposed.

8.3.2.8 Method of Testing for Main Procedure

In addition to the requirements of BS 4515-1, add the following clauses:

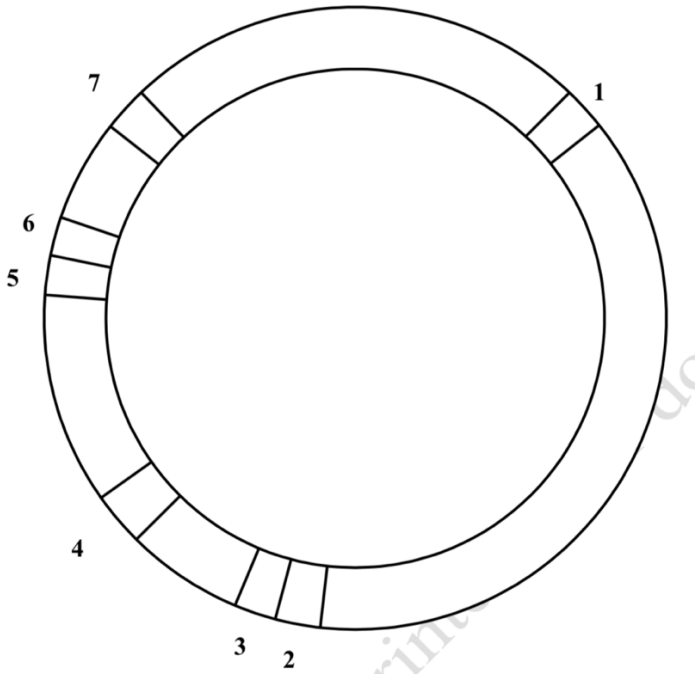
Where CTOD testing is specified, the extent of testing shall be a minimum of one set of three weld metal centre line specimens and one set of three fusion line specimens cut from the area of highest heat input (usually 180°). For mechanised welding procedures, the minimum additional specimens required for materials toughness testing shall be as given in Table 8 of this specification or shall be as agreed with the Gas Transporter prior to welding of the test joint.

CTOD testing of the weld metal and heat affected zone shall be carried out at the minimum design temperature in accordance with BS EN ISO 15653 under displacement control. The fracture toughness shall be reported in terms of the crack tip opening displacement (CTOD) and the J-integral values. The test specimens shall be cut from the test joint at the locations shown in Figure 1 of this specification. The specimens shall be notched as shown in Figure 2. All-weld tensile specimens shall be cut from the test joint at the location shown in Figure 1 of this specification and shall be prepared and tested in accordance with BS EN ISO 5178 and BS EN ISO 6892-1. The primary purpose of the all-weld tensile test is to enable calculation of fracture toughness to be made.

Table 8 — Additional Test Specimens for Procedure Approval of Mechanised or Semi-Automatic Butt Welds.

Number of specimens			
All weld tensile[1]	**CTOD weld centre line[2, 4]**	**CTOD weld HAZ[2, 4]**	**Macro/ Hardness[3]**
2	*6	*6	1

1) All weld tensile specimens required for yield strength confirmation and CTOD calculation.
2) CTOD (Bx2B, SENB) tested at the minimum design temperature under displacement control.
3) Macro specimen (and hardness survey) at butt weld and pipe seam weld junction.
4) *The number of CTOD specimens required shall be agreed with the Gas Transporter prior to production of test welds.



Specimen Location	Position	Mechanical Test
1	45°	All-weld tensile
2	180°	Set of CTOD, weld centre line tests
3	180°	Set of CTOD, weld heat affected zone tests
4	225°	All-weld tensile
5	270°	Set of CTOD, weld centre line tests
6	270°	Set of CTOD, weld heat affected zone tests
7	Pipe weld seam	Macro examination and hardness

Notes:

a) The above specimens represent the minimum requirements and may increase depending on wall thickness and the use of any mixed welding processes.

b) The Gas Transporter will specify the number of CTOD specimens required. As a minimum one set of weld metal and one set of HAZ specimens shall be tested from the area of highest heat input.

c) CTOD (Bx2B, SENB) tested at the minimum design temperature under displacement control.

d) The all-weld tensile specimens shall be taken from as high up in the weld body as practicably possible without compromising specimen size.

e) The hardness survey shall be made on the macro-specimen.

f) Specimens from location 2 will only be required when batch testing of welding consumables is specified by the Gas Transporter.

Figure 1. Location of Additional Test Specimens for Butt Welds Made With a Mechanised Welding Process.

8.3.2.9 Forged Set-On Branch Attachments

In addition to the requirements of BS 4515-1, add the following clauses:

The Gas Transporter Specification GIS/PW11: Part 1 limits the maximum size of a set-on fitting to 88.9 mm outside diameter. The destructive tests required when qualifying a small diameter branch attachment welding procedure, e.g., a weld-o-let (within the range 26.7 – 88.9 mm OD), shall consist of two macro sections taken 90º apart from each other (i.e., one aligned with the pipe axis and one transverse to the skirt of the weld). A hardness survey, in accordance with BS 4515-1 Figure 8, is required on both macro sections.

8.3.2.10 Forged Set-In Branch Attachments

In addition to the requirements of BS 4515-1, add the following clauses:

The destructive tests required for the qualification of the skirt and branch welds of forged set-in branch attachments (i.e., sweep-o-let fittings) shall be agreed with the Gas Transporter prior to producing the test welds. As a minimum, the skirt weld shall be tested at two locations 90° apart, one from the crotch (i.e., where the skirt weld runs transverse to the run pipe axis) and one from the saddle (i.e., where the skirt weld runs parallel to the run pipe axis). The following tests shall be performed:

a) Macro examination and hardness

b) Three sets of Charpy impact tests
(i.e., weld centre line, fusion line pipe side & fusion line fitting side)

c) Transverse tensile (reduced section if necessary)

d) All-weld metal tensile from saddle location only (in accordance with 8.3.2 ‘All-Weld Tensile Testing’)

Charpy specimens shall be located within 2 mm of the root surface of the weld. When pipe thickness exceeds 20 mm, two additional sets of specimens (i.e., weld metal and fusion line fitting side) are required at both the crotch and the saddle locations. These additional specimens shall be taken within 1 – 2 mm of the pipe outside surface.

8.4 Testing of Repair Welds For Procedure Qualification

8.4.2 Non-Destructive Testing

The test pieces shall be examined as stated in BS 4515-1, section 8.4.2. However, the examination techniques used shall be in accordance with GIS/NDT2.

8.4.3 Destructive Testing

8.4.3.1 General

In addition to the requirements of BS 4515-1:

Where the repair welding process or procedure is not identical to the mechanised or semi-mechanised welding procedure used to make the original joint, the number of test specimens for testing of the repair test weld shall be as specified in Table 9 of this specification.

Table 9. Test Specimens for Procedure Approval of Repair Welds Not Identical to the Original Mechanised or Semi-Automatic Welding Procedure.

Type of Weld Repair	Type of Test and Number of Specimens						
	All-Weld Tensile	T/V Tensile	Charpy Weld	Charpy FL	CTOD Weld (b)	CTOD FL (b)	Macro/ HV (a)
Full-Penetration Repair	1	1	1 set	1 set	3	3	1
Partial-Pen. Repair	1	1	1 set	2 sets	3	6	1
Internal Root Repair	—	—	—	—	—	—	1

Notes:

a) Hardness survey to be made on macro-examination specimen.

b) The number of CTOD specimens required shall be agreed with the Gas Transporter prior to the welding of any test welds. Refer to Figure 2 and Figure 3 for notch locations.

Test specimens from a two-pass internal repair test weld (see 8.1.1 (k) and (l) of this specification) shall be cut from the repair test weld from the applicable location shown in BS 4515-1, Figure 4 b.

Add the following clause to BS 4515-1:

8.4.3.6 Method of CTOD Testing for Repair Procedures

When material fracture toughness testing has been used to obtain the approval of the main procedure, the following specimens shall be removed from each repair procedure test weld and tested at the minimum design temperature:

a) Group A – Three preferred geometry fracture mechanics specimens with the notch positioned along the centreline of the repair weld as shown in Figure 2 of this specification.

b) Group B – Three preferred geometry fracture mechanics specimens with the notch positioned such that the fusion boundary between the repair weld and the original weld intersects the notch tip at the mid-depth position of the repair weld as shown in Figure 3 of this specification.

c) Group C – Three preferred geometry fracture mechanics specimens with the notch positioned such that the fusion boundary between the repair weld and the pipe material intersects the notch tip at the mid-depth position of the repair weld as shown in Figure 5 of this specification.

d) For repair weld qualification of mechanised welds, the minimum number of CTOD specimens and other tests required shall be as listed in Table 9 of this specification. Any variation to the number of specimens tested shall be agreed with the Gas Transporter prior to welding of the test joint.

e) The acceptance and re-testing criteria for all repair weld procedures are identical to the requirements of the original welding procedure.

f) When material fracture toughness testing of the main procedure is required by the Gas Transporter for information purposes only, the extent of repair weld CTOD testing may be reduced by agreement.

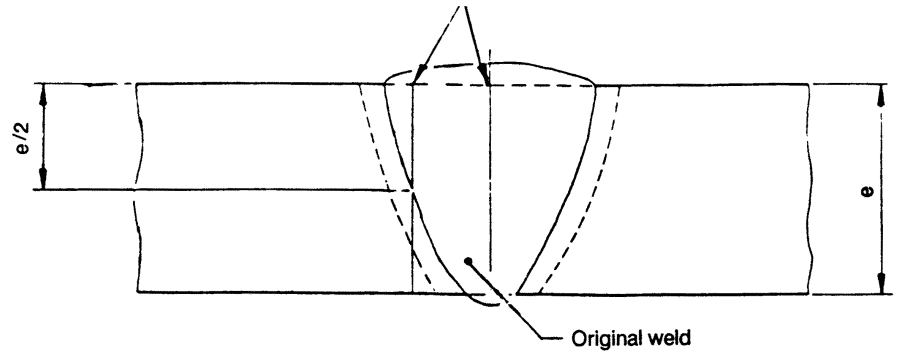


Figure 2. Position of Crack Tip Opening Displacement Specimen Notch for Assessing Original Butt Weld or Full Penetration Repair Weld.

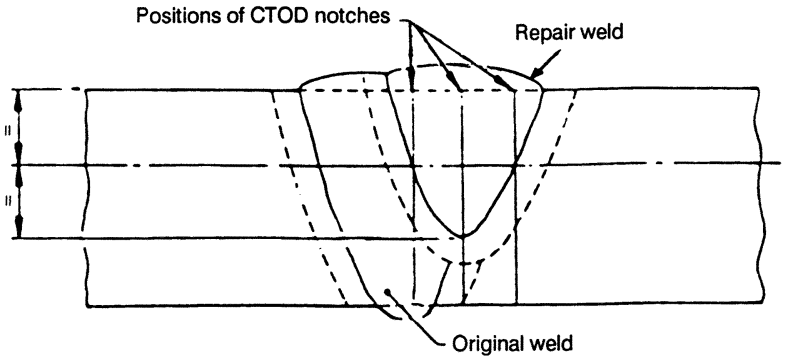


Figure 3. Position of Crack Tip Opening Displacement Specimen Notch for Assessing Partial-Penetration Repair Weld.

8.5 Testing of Fillet Welds For Procedure Qualification

8.5.1 Non-Destructive Testing

The test pieces shall be examined as stated in BS 4515-1, 8.5.1. However, the examination techniques used shall be in accordance with GIS/NDT2.

8.5.2 Destructive Testing of Fillet Welds

8.5.2.3 Macro-Examination

In addition to the requirements of BS 4515-1:

Photographs of each macro specimen showing the location of the hardness impressions shall be provided with the mechanical test records.

BS 4515-1 requires that macro test specimens shall be examined at a magnification of x5. In addition to this, the degree of photographic magnification used must be recorded accurately on the test report.

9 TESTING, QUALIFICATION AND APPROVAL OF WELDERS

In addition to the requirements of BS 4515-1:

9.1 General

For the purpose of welder qualification, set-on branch attachment welding shall be classed as butt welds.

Repair welders shall be separately qualified. The preparation of the excavation shall be included in the test.

9.2 Butt Joints

9.2.2 Positional Welding

For pipe butt welds (category (a) in BS 4515-1) the welder's test shall include the 6 o'clock and 12 o'clock pipe positions.

For vertical up welding, both manual and semi-automatic, parameter checks shall be recorded to confirm that the heat input values have been maintained within the range of the qualified WPS.

No dressing or remediation is permitted on the [internal] root bead during the qualification test.

9.3 Branch Connections

For branch connections (category (b) in BS 4515-1) the welder's test shall include the relevant positions to be welded in production.

9.4 Fillet Welds for Sleeves, Sockets, Slip-on Flanges or Other Attachments

9.4.3 Fillet Welds in All Positions

For fillet welds (category (c) in BS 4515-1) the welder's test shall include the relevant positions to be welded in production.

9.6 Non-Destructive Testing

The test pieces shall be examined as stated in BS 4515-1, section 9.6. However, the examination techniques used shall be in accordance with GIS/NDT2.

9.7 Destructive Testing

When the primary inspection method is manual ultrasonic testing, bend tests shall be performed in accordance with the requirements of BS EN ISO 9606-1.

Test welds made using MAG welding (processes 131, 135, and 138) shall be subject to bend testing performed in accordance with the requirements of BS EN ISO 9606-1.

9.10 Mechanised Welding

Add the following clause to BS 4515-1:

Welder qualification testing shall be specific to the make and model of mechanised welding equipment.

For single process mechanised welding, each welder shall be qualified for all parts of the operation of making the joint (except where they are not required to make an internally deposited root pass).

A theory test should be considered to confirm that the welder fully understands the equipment arrangement, operation, maintenance, and identification of filler metals & shielding gases.

Reference shall be made to the relevant provisions of BS EN ISO 14732.

10 PRODUCTION WELDING

10.1 Proximity of Welds

Replace the existing text in BS 4515-1 with:

a) Adjacent circumferential welds shall be separated by the lesser of one pipe diameter or 750 mm (except where fittings with shorter pipe-pups are used). The Gas Transporter shall be informed of any proposed deviation to this requirement and will decide whether the joint may be welded or whether further modification to the pipeline or pipework is required to ensure compliance.

b) Fittings equal to or greater than 457.0 mm outside diameter, which are to be used in a pipeline, shall have pipe-pups welded to them under fabrication shop conditions before being incorporated into the pipeline, unless otherwise agreed by the Gas Transporter. The pup length shall be not less than 250 mm. When space restrictions prohibit fittings with pipe-pups being installed, or results in a fitting being welded to a fitting, special care must be taken with the joint set-up and the application of pre-heat. Induction bends with tangent lengths do not need to be pupped.

c) Set-on welded attachments and fillet welds shall have a weld toe-to-toe distance from any other weld of not less than four times the pipe thickness, or 25 mm, whichever is the greater.

d) Full penetration welds (e.g., forged set-in branches adjacent to circumferential or longitudinal welds) must normally be not less than 100 mm apart. Should special circumstances require closer proximity, these shall be subject to the approval by the Gas Transporter.

The production welding route, or order, shall be planned to ensure that, where necessary, back grinding of root beads and inspection of the weld root is achievable. This is particularly important for fittings (see Table 1 (s) of this specification). To facilitate welding, repair and inspection, the use of pipe-pups interposed between fittings and branches is desirable.

10.2 Pipe End Preparation

In addition to the requirements of BS 4515-1:

The NDT requirements for the ultrasonic testing of cut pipe ends and areas of pipe prepared for welded attachments are specified in clause 10.8 of GIS/NDT2. The presence of any laminations shall be deemed unacceptable.

Submerged arc welded (SAW) seam welds shall be dressed flush with the pipe, inside and outside, for a distance of 100 mm from the pipe end during the bevelling operation, and prior to fit-up.

10.3 Fusion Faces

Add to the existing text in BS 4515-1:

a) Fusion faces not complying with the requirements of clauses 10.2 and 10.3 shall be re- prepared before welding.

b) All coatings other than fusion-bonded epoxy (FBE) shall be cut-back not less than 150 mm.

c) Except for FBE, all coatings and their adhesive mastics shall be prevented from attaining temperatures sufficient to cause the emission of toxic fumes. Where a non-FBE coating has been cut back, all traces of adhesive mastic must be removed. Scraping, blast cleaning or a suitable stripping agent may be acceptable. Heating methods shall not be used for removal of coatings.

d) Consideration shall be given to providing personnel protection and effective collection and disposal of fumes in all cases where a polyethylene or urethane coating may be heated to temperatures that cause the emission of toxic fumes. Fumes from coating removal and welding can be particularly hazardous in confined spaces.

10.4 Alignment

In addition to the requirements of BS 4515-1:

a) No force shall be used to spring or superimpose additional stresses on any component during construction.

b) Mitres at welded joints are not permitted. Angular misalignment at the weld of less than 3° is not classed as a mitre and is acceptable provided that the misalignment is equally distributed on both sides of the joint to a maximum of 1.5° per side.

c) Prior to welding commencing the contractor shall submit a method statement for the correction of excessive joint misalignment for approval by the Gas Transporter.

d) To prevent unacceptable stress concentrations in the weld joint, line up clamps shall be used to support and align the weld joint wherever possible. When the internal root offset, after rotation of the abutting ends to achieve best alignment, is greater than the tolerance range given in Table 10 of this specification, excessive misalignment shall be corrected in accordance with the approved method statement before welding.

e) For pipes of different nominal thickness and the same outside diameter, alignment shall be achieved in accordance with GIS/P16 specification, except where, to facilitate manual phased array inspection, the thicker pipe is counter-bored to match wall thickness to the thinner pipe over a distance of 50 mm from the weld preparation root face.

f) For socket joints, the pipe end shall be inserted fully into the socket and then withdrawn 2–2.5 mm as shown in Figure 4 of this specification. This gap is vital to the integrity of the finished joint. The assembly shall be checked for alignment and any necessary adjustment made prior to tack welding (see 10.6 of this specification).

g) When required by the Gas Transporter, the contractor shall demonstrate that the correct alignment and expansion spacing has been achieved for socket welded joints by destructively testing a production weld chosen at random by the Gas Transporter or their representative. Alternatively, the joint can be examined by radiography and the original fit-up confirmed.

h) For submerged arc welded helical (SAWH) i.e., spiral line pipe, and when joining line pipe to a prefabricated fitting short pipe pup piece, the position of the weld seams at the mating faces of adjacent pipes shall be offset by a distance of not less than 100 mm.

Table 10. Weld Joint Alignment Tolerances.

Wall Thickness, *t* (mm)	**Permitted Misalignment of Abutting Surfaces**[(a)]	
	External	**Internal**
< 10	0.3 x *t*	1.5 mm around entire circumference
10 – 24	3.0 mm	2 mm over a circumferential length equivalent to the nominal pipe diameter
> 24	0.125 x *t*	2.5 mm over a circumferential length equivalent to 1/3 of the nominal pipe diameter.
(a) Unless a smaller tolerance is specified by the pipe work designer.		

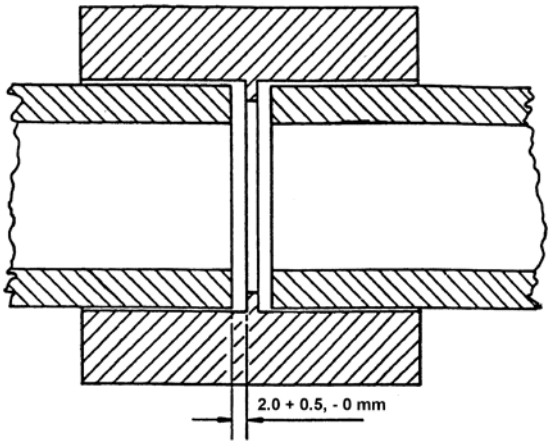


Figure 4. Socket Weld Configuration Prior to Welding.

10.5 Line-Up Clamps and Pipe Supports

10.5.1 Use of Line-Up Clamps

In addition to the requirements of BS 4515-1:

Precautions shall be taken to minimise pipe coating damage when external line-up clamps are used. All external line-up clamps and earth return clamps shall be lifted into place and shall not be dragged along the pipe surface. To eliminate coating damage when using mechanised welding machines, the support frames/bands shall be adequately padded and the buttons on externally fitted bands shall be profiled to protect the coating surface from damage.

10.5.2 Removal of Pipe Supports

In addition to the requirements of BS 4515-1:

The pipeline shall remain fully supported throughout the welding, inspection, and coating operations.

10.6 Tack Welds

In addition to the requirements of BS 4515-1:

a) Tack welding shall be carried out in accordance with that part of the approved welding procedure that is to be used for the root run. In all cases only qualified welders may carry out tack welding. On diameters equal to or greater than 406.4 mm OD, at least four equally spaced tack welds, each not less than 50 mm length, shall be used.

b) ‘Bullet’ tack welding may only be carried out when agreed by the Gas Transporter. The contractor shall submit a written procedure for the Gas Transporters approval, which as a minimum, must describe the following items:

   i. The welding procedure to be used.

   ii. The method of bullet tack welding.

   iii. The type and size of material to be used as bridging pieces.

   iv. The pre-heating temperature to be applied before tack-welding.

v. The sequence and method of bullet tack removal.

vi. The maximum diameter of pipe that may be bullet tack welded and then moved to another position or location to complete the weld.

vii. When the approved welding procedure uses low hydrogen consumables for the fill and cap passes, bullet tacking must take place using the same type of consumable.

c) When socket joints have reached the minimum pre-heat temperature, the assembly may be tack welded in order to maintain alignment during the welding cycle. A minimum of two tack welds shall be used, each not less than 12 mm in length. The tack welds shall be equally spaced. When welding pipes in the horizontal position, the tack welds shall be placed at the 3 o'clock and 9 o'clock positions. The tacks shall be ground smooth and the ends tapered to ensure fusion of the remainder of the weld run.

d) Should excessive pipe end magnetism prevent satisfactory weld deposition, the affected pipe or component shall be de-magnetised immediately prior to welding of the joint (see Appendix D of this specification).

10.7 Working Clearance

In addition to the requirements of BS 4515-1:

a) Excavations must meet the current statutory and Gas Transporter requirements. For recommended dimensions of bell-hole excavations see Appendix E of this specification. Background lighting should be in accordance with Table 2 of GIS/PM/EL1, for exterior illumination levels for working areas. Refer to GIS/NDT2 for the required viewing conditions for visual and magnetic particle inspection.

b) Weather protection canopies or habitats shall be of a clear flame-retardant material or have clear windows that allow an unobstructed view of the operation. The canopies or habitats shall be of adequate size to provide unhindered access for all heating, welding, and inspection activities. Provision shall be made for adequate welding fume extraction.

10.8 Stray Arcs

In addition to the requirements of BS 4515-1:

a) In order to reduce the risk of unwanted arc strikes, electrode holders shall be of the fully insulated type.

b) Not more than one arc strike per weld may be repaired. Two or more arc strikes will be cause for the complete removal of the weld and damaged pipe material.

c) With the prior agreement of the Gas Transporter in each case, weld deposition repairs to restore pipe wall thickness shall only be carried out using an approved welding procedure. The repaired area shall be examined using complementary NDT methods capable of detecting surface and sub-surface weld defects in any orientation.

d) The application of weld deposition repairs is limited to pipe material grade less than or equal to L450. Weld deposition repairs shall not be applied to pipelines that are designed to accommodate pressure cycling or where it could affect the pipeline fatigue life.

e) Low hydrogen electrodes/processes shall be used for weld deposition repairs.

f) Arc strikes arising from copper (e.g., contact tips) shall be subject to thorough inspection, as this form of arc strike invariably causes cracking in the parent metal.

10.9 Weather Conditions

In addition to the requirements of BS 4515-1:

The Gas Transporter will decide, in consultation with the contractor, whether weather conditions are such that work has to cease or whether with adequate weather protection, welding can proceed or continue.

10.10 Preheating and Post Weld Heat Treatment

10.10.1 General

In addition to the requirements of BS 4515-1:

Guidance is given in Appendix C of this specification for the post weld heat treatment of welded joints. When required, the PWHT welding procedure shall be in accordance with an appropriate standard, e.g., BS 2633.

10.10.2 Preheating

In addition to the requirements of BS 4515-1:

The minimum pre-heating temperature shall be determined by temperature-indicating crayons (which melt when the required temperature is reached), contact thermometer or by suitably attached thermocouples. Crayons or paints that indicate temperature by colour change, and infra-red pyrometers are not permitted.

For all pipe-to-pipe joints, fittings and socket assemblies, the following minimum preheat temperatures shall apply (unless a higher pre-heat temperature is required based on the results of weldability trials or if specified in the contractor's proposed welding procedure):

10.10.2.1 Pipe-to-Pipe Joints

Pipe material greater than or equal to L450 (or X65) grade and having a wall thickness greater than or equal to 19.1 mm:

- A minimum preheat temperature of 100°C shall be applied when cellulosic welding procedures are used.
- When approved by the Gas Transporter, a minimum preheat temperature of 80°C may be applied where the fill and cap passes are deposited using low hydrogen consumables.

A minimum preheat temperature of 100°C shall be used for pipe material of L555 (or X80) grade regardless of wall thickness.

For all other pipe grades (less than L450 or X65) and wall thickness combinations, a minimum preheat temperature of 50°C shall be used.

10.10.2.2 Pipe-to-Fitting, or Fitting-to-Fitting Joints

The weld procedure for fittings (other than socket assemblies), shall include a minimum preheat and weld inter-pass temperature requirement of 150°C.

10.10.2.3 Socket Joint Assemblies

Socket joint assemblies shall be preheated to 75 ºC minimum. Care shall be exercised to prevent overheating of the pipe and fitting. Normal practice is to limit the maximum interpass temperature to 150°C.

When welding socket assemblies adjacent to isolation joints or ball valves, the body of the component shall not be allowed to exceed a temperature of 50°C for an isolation joint or 100°C for a ball valve respectively. These components shall only be welded under constant supervision.

10.10.2.4 Air-Arc Gouging

When air-arc gouging is undertaken, both components shall be pre-heated to the minimum temperature specified in the repair welding procedure prior to air-arc gouging.

10.10.2.5 Weld Inter-Pass Temperature

The weld inter-pass temperature must not fall below the minimum pre-heat temperature specified on the approved welding procedure specification. Any variation proposed to this requirement for pipe welding must be approved by the Gas Transporter and be qualified at the lower temperature during the welding procedure test.

10.10.3 Post Weld Heat Treatment Temperatures

In addition to the requirements of BS 4515-1:

Any proposal to use alternative methods for measuring the post-weld heat treatment temperature shall be agreed by the Gas Transporter.

10.11 Branches

In addition to the requirements of BS 4515-1:

All branches shall be made with specialised fittings (e.g., forged or pressed tees, forged set-in or set-on components) and these shall be specified in the design of the fabrication.

10.11.2 Spacing of Branches

In addition to the requirements of BS 4515-1:

See clause 10.1 of BS 4515-1, and this specification.

10.11.3 Joint Preparation

The NDT requirements for the ultrasonic testing of areas of pipe prepared for welded attachments are specified in clause 10.8 of GIS/NDT2. The presence of any laminations is not permitted.

10.12 Inter-Run Cleaning

In addition to the requirements of BS 4515-1:

Delete the word “cracks” from the second paragraph and insert the following text at the end of the final paragraph:

The cause of any visible cracks or crack-like indications found during welding shall be investigated immediately and reported to the Gas Transporter or their Representative. Should a crack be confirmed then the complete joint shall be cut-out and removed. Where a crack-like indication is proved not to be a crack, it may be removed by grinding and the joint completed. However, any delay to the normal welding cycle shall be within the maximum welding time-lapse requirements, if specified.

10.13 Partially Completed Joints

In addition to the requirements of BS 4515-1, section 10.13:

Add the following requirements to item (a):

Unless otherwise agreed by the Gas Transporter, the joint shall be completed in the specified heat cycle (see 8.1.1 items 5, 6, 7 and 16 of this specification).

Any welded joint carried out in a trench or excavation shall have at least 50% of the weld joint thickness

completed before being allowed to cool to ambient temperature.

In excavations, where pipe fabrications are to be joined to a fixed end and the pipe support can only be maintained throughout by mechanical lifting equipment, this joint shall be completed in one welding cycle before being lowering off.

Add the following requirements to item (c):

Any welded joint that will be left partially completed must be fully supported throughout each production stage i.e., before being allowed to cool to ambient temperature, during re-heating and until the weld is completed. The method of support must be clearly defined by a method statement and submitted to the Gas Transporter for approval.

Prior to re-heating partially completed welded joints, the joint supports must be checked to ensure that the support has been maintained. This is required to prevent potential failure and separation of a partially completed weld joint during work as a result of unacceptable stress levels.

Golden welds shall be completed in a single heat cycle.

11 INSPECTION AND TESTING OF WELDS

11.1 General

In addition to the requirements of BS 4515-1:

Additional or alternative requirements to clause 11.1 of BS 4515-1 are specified in Gas Transporter specification GIS/NDT2 and in clause 11.1, Table 1, r) & s) and Table 2 z) of this specification.

For tie-in welds that will be hydrostatically tested, any additional NDT requirements shall be agreed between the Gas Transporter and the contractor before production welding commences.

Welds that will not be hydrostatically tested (i.e., golden welds), shall be subjected to supplementary NDT. The supplementary NDT method shall differ from the initial NDT method adopted and shall have a facility to produce a reviewable record. The following methods may be used for supplementary NDT:

- X-Radiography
- Automatic ultrasonic testing (AUT)
- Manual Phased Array ultrasonic inspection

In addition, the weld cap of golden welds shall be examined by MPI.

12 ACCEPTANCE AND RECTIFICATION OF WELDS

12.1.2 Acceptance Criteria Based on Quality Control

The following additional requirements to Table 9 of BS 4515-1 shall apply:

Flaw Type		Acceptance Criteria
External Profile	a	External weld reinforcement shall not exceed 3 mm in height.
Cracks	g	Welds having flaws identified positively as cracks shall be cut-out. Crater cracks greater than 5 mm in any direction shall be cut out. Crater cracks less than or equal to 5 mm in any direction shall be removed and repaired, or cut out.
Isolated copper inclusions	k	Not permitted. If present, all traces of copper shall be removed and the weld repaired.

When the primary inspection method is ultrasonic testing, the acceptance criteria shall be agreed with the Gas Transporter before construction commences.

12.1.3 Acceptance Criteria Based on Engineering Critical Assessment

When the Gas Transporter specifies that an engineering critical assessment (ECA) is to be used to establish acceptance criteria, it shall be applied in accordance with the European Pipeline Research Group (EPRG) Tier 2 requirement (contained in BS EN 12732) or in accordance with BS 7910:2005+A1, as agreed with the Gas Transporter.

12.2 Rectification of Welds

12.2.3 Qualification

In addition to the requirements of BS 4515-1:

Where it is proposed to carry out a shallow repair to the internal surface of the original weld, the test weld to qualify this type of repair shall be made into an excavation sufficiently deep to accommodate two weld runs one on top of the other (see 8.1.1 (12)). Internal repairs consisting of three or more weld runs must be treated as a multi-pass back-weld repair and shall be qualified in accordance with BS 4515-1, 8.4.3.1 and Figure 4 (b).

Single run repair welds are not permitted.

12.2.4 Re-Welding

In addition to the requirements of BS 4515-1:

Root sealing repair deposits are not permitted (see 8.1.1 (9) and 8.4.3 of this specification). For mechanised welding systems that deposit the root bead internally, remedial work may be carried out while the weld inter

pass temperature is still above the minimum stated in the approved welding procedure.

Remedial welding procedures shall be approved by the Gas Transporter and qualified on test welds that simulate the type of alternative repair (see 8.1.1 (10) and (11) of this specification). For production welding a record of all remedial welding shall be made.

During production welding, single woven and multiple pass external weld cap repairs shall match the original weld profile and width (see 8.1.1 (8) of this specification).

Internal repairs may only be carried out when approved by the Gas Transporter and subject to a site-specific risk assessment.

13 PROJECT RECORDS

Records shall be produced by the manufacturer or contractor to confirm that the requirements specified in this document for welding, examination, inspection and testing of each weld have been met. The records shall ensure complete identification and traceability for all activities associated with the planning, design, qualification, execution, inspection and testing of the welded components.

The records shall include but not be limited to, when applicable:

- Quality plan
- Material inspection documents
- Welding consumable documents
- Preliminary welding procedure specification (pWPS)
- Welding procedure qualification records (WPQR)
- Welding procedure specifications (WPS)
- Heat-treatment procedure specification and records
- Welder or welding-operator qualification certificates
- Weld surveillance records
- Fabrication & Tie-in reports
- Non-destructive testing and destructive testing procedures and reports
- Non-destructive testing personnel certificates
- Dimensional reports
- Records of remedial welding, weld repairs and non-conformance reports
- Any other pertinent documents, when required

APPENDIX A – REFERENCES

In addition to those documents referenced in BS 4515-1: 2009 section 2, this Specification makes reference to the documents listed below.

A.1 External Documents

ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe
BS 2633	Specification for Class 1 arc welding of ferritic steel pipe work for carrying fluids.
BS 4515-1: 2009	Specification for welding of steel pipelines on land and offshore. Carbon and carbon manganese steel pipelines.
BS EN 876	Destructive tests on welds in metallic materials. Longitudinal tensile test on weld metal in fusion welded joints
BS EN 1011-2	Welding. Recommendations for welding metallic materials. Arc welding of ferritic steels.
BS EN 10002-1	Tensile testing of metallic materials - Method of test at ambient temperature
BS EN 10204	Metallic products. Types of inspection documents.
BS EN 12732	Gas infrastructure – Welding steel pipework. Functional requirements.
BS EN ISO 636	Welding consumables. Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels. Classification
BS EN ISO 3834-2	Quality requirements for fusion welding of metallic materials - Comprehensive quality requirements
BS EN ISO 5178	Destructive tests on welds in metallic materials. Longitudinal tensile test on weld metal in fusion welded joints.
BS EN ISO 6892-1	Metallic materials. Tensile testing - Method of test at room temperature
BS EN ISO 6947	Welding and allied processes — Welding positions
BS EN ISO 9606	Qualification testing of welders. Fusion welding – Steels
BS EN ISO 10012	Measurement management systems — Requirements for measurement processes and measuring equipment
BS 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
BS EN ISO 14341	Welding consumables. Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels. Classification
BS EN ISO 14732	Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials
BS EN ISO 15653	Metallic materials. Method of test for the determination of quasistatic

	fracture toughness of welds
BS EN ISO 17636-1	Non-destructive testing of welds. Radiographic testing - X- and gamma-ray techniques with film
BS EN ISO 18275:	Welding consumables. Covered electrodes for manual metal arc welding of high-strength steels. Classification
BS EN ISO 18276	Welding consumables. Tubular cored electrodes for gas-shielded and non-gas shielded metal arc welding of high strength steels. Classification.
BS EN ISO 26304	Welding consumables - Solid wire electrodes, tubular cored electrodes and electrode-flux combinations for submerged arc welding of high strength steels - Classification
PD ISO/TR 18491	Welding and allied processes — Guidelines for measurement of welding energies

A.2 IGEM Documents

IGEM/TD/1	The Institute of Gas Engineers & Managers Recommendations on Transmission and Distribution Practice – Steel Pipelines for High Pressure Gas Transmission.

A.3 Gas Transporter Documents

GIS/DAT6	Standard sizes of carbon and carbon manganese steel pipe for operating pressures greater than 7 bar
GIS/B11	Carbon and carbon manganese steel bends 200 mm nominal size and above produced from pipe by induction bending for operating pressures greater than 7 bar.
GIS/B12	Steel bends, tees, reducers and end caps for operating pressures greater than 7 bar.
GIS/F1	Carbon and carbon manganese steel forgings and forged components for operating pressures greater than 7 bar.
GIS/L3	Procurement of Line Pipe for Use in European Onshore Natural Gas Transmission and Distribution Pipelines (Supplement to EN ISO 3183)
GIS/NDT2	Non-destructive testing of welds on construction and fabrication projects.
GIS/P16	The dimensions and applications of standard weld end preparations for steel pipe, fittings and valves.
GIS/PM/EL1	Procedures for the selection, maintenance and installation of luminaires and lamps.
GIS/PW11: Part 1	Pipework systems operating at pressures exceeding 7 bar Part 1 – Design and materials.
GIS/Q10	The sampling and testing of steel pipe and fitting materials used in gas pipelines and pipework designed to operate at pressures above 2 bar
TS-C4Gas-PIP0v9	Steel Pipes for Pipelines Common Requirements

T/SP/PIP1	Steel Line Pipe for Natural Gas Pipelines Operating at Pressures Greater than 7 Bar (with Specific Requirements to BS EN ISO 3183:2012 Including Annex M)

A.4 Statutory Instrument

SI No 825	Pipeline Safety Regulations 1996

A.5 NSAI Documents

I.S. 328	Gas Transmission Pipelines and Pipeline Installations

APPENDIX B – DEFINITIONS

Bell-hole: An excavation that permits access to below ground pipe work to facilitate the welding, inspection, coating or any other activity required to conduct the works.

Consistency trials: A series of consecutive welds of repeatable quality made to the satisfaction of the Gas Transporter, to demonstrate that the proposed welding process or welding system has the technical capability to consistently produce sound welds with the desired metallurgical properties using the approved welding procedure.

Dressing: Light grinding in the weld area where the parent pipe or fitting is not reduced in wall thickness below the minimum allowed by the relevant specification.

Golden weld: A pressure retaining production weld which cannot be hydrotested.

Internal repair: A repair from the internal surface of the original weld consisting of two weld runs only, one on top of the other.

Inspector: The body, association or employee which monitors that the materials and construction are in accordance with this specification.

Low hydrogen process: For manual welding processes considered to be a diffusible hydrogen content equal to or less than 5 ml/100 g of deposited weld metal.

For the submerged-arc welding process the wire and flux combination shall produce a diffusible hydrogen content equal to or less than 10 ml/100 g of deposited weld metal.

MIG (131), MAG (135, 136, & 138) and TIG (141) are considered to be low hydrogen processes.

Nominal Diameter (DN): The metric equivalent of nominal pipe size (NPS) is called DN or "diametre nominel". The metric designations conform to International Standards Organisation (ISO 6708), which defines the nominal size (DN) as an alphanumeric designation of size for reference purposes. It comprises the letters DN followed by a dimensionless whole number which is indirectly related to the physical size in millimeters of the bore (ID) or outside diameter (OD) of the end connections.
See reference table on following page.

Pipeline: The extent of all fabrication up to and including block valve assemblies, terminating at the attachment weld to a pig trap as defined by the Pipeline Safety Regulations 1996 or as modified by the Gas Transporter.

Remedial welding: Welding carried out to correct visual defects while the weld is still above the original minimum inter-pass temperature stated in the approved welding procedure.

Statutory Instrument: By-law, order or regulation issued by Government or its agencies that sets out responsibilities and the measures that must be taken for the enactment or enforcement of a specific statute.

Supply condition: This term is taken to mean the heat-treated condition of the materials to be welded (e.g., as rolled, hot rolled, normalized (N), thermomechanically control rolled (M), and quench & tempered (Q)).

Tie-in weld: A welded joint that connects two sections of pipe work together in such a manner that direct access to the internal surface of the joint is precluded**.**

Nominal Diameter	Outside Diameter, D (mm)	NPS	OD (inches)
DN15	21.3	½"	0.840"
DN20	26.7	¾"	1.050"
DN25	33.4	1"	1.315"
DN40	48.3	1½"	1.900"
DN50	60.3	2"	2.375"
DN80	88.9	3"	3.500"
DN100	114.3	4"	4.500"
DN150	168.3	6"	6.625"
DN200	219.1	8"	8.625"
DN250	273.1	10"	10.750"
DN300	323.9	12"	12.750"
DN400	406.4	16"	16.000"
DN450	457.0	18"	18.000"
DN600	610	24"	24.000"
DN750	762	30"	30.000"
DN900	914	36"	36.000"
DN1050	1067	42"	42.000"
DN1200	1219	48"	48.000"

Table 11. Pipe diameters (Ref. T/SP/DAT6 and ANSI B36.10).

APPENDIX C – GUIDANCE ON POST WELD HEAT TREATMENT

C.1. Post-weld heat treatment of circumferential butt welds may be required in the following circumstances:

a) When the carbon equivalent of the material based on ladle analysis is greater than 0.53%.

b) When the pipe thickness is greater than 32 mm.

c) When hardness limitations cannot be met in the as-welded condition.

When materials of differing thickness or carbon equivalents are to be welded, the greater thickness or carbon equivalent should be used in determining the post-weld heat treatment requirements.

Thermomechanical Controlled Processed (TMCP) steels are not normally subject to post weld heat treatment. If it is necessary to carry out post weld heat treatment on these types of steel, then specialist advice must be sought.

Quench and tempered steels may be subject to post weld heat treatment, however close attention must be paid to the soak temperature; making sure that it does not exceed the temper temperature.

C.2. When residual stresses are to be controlled, a stress relieving heat treatment can be performed. Typically, this will involve heating the pipe or component to a temperature within the range 580–620°C and maintaining this ‘soak’ temperature for a period of time, followed by controlled cooling.

C.3. When there is a high risk of cold cracking, hydrogen release may be accelerated by either maintaining the minimum inter-pass temperature or raising the temperature to 200–300°C immediately after welding and before the weld region cools to below the minimum inter-pass temperature. The duration of post-heating should be at least 2 hours and is a function of the thickness. Large thicknesses require temperatures at the upper end of the stated range as well as prolonged post-heating times.

C.4. The methods of applying heat treatment are:

d) Furnace. Full body, i.e., the whole component is placed into the furnace.

e) Induction coils. Usually localised heating rather than full body.

f) Electrical resistance mats. Usually localised heating rather than full body.

C.5. Post weld heat treatment is an essential variable, and therefore any production weld which is going to be subject to post weld heat treatment shall be fully tested during WPQT. When designing the heat treatment parameters consideration should be given to the possibility of needing to carry out repair welding after post weld heat treatment, and therefore the need for a second heat treatment cycle.

C.6. Monitoring and control of temperature is very important. A time-temperature chart shall be produced for each post weld heat treatment operation.

C.7. Structural support of the work-piece is essential, as elevated temperatures above circa 300ºC lead to a progressive reduction in mechanical strength of the steel.

C.8. Reference should be made to an appropriate standard (e.g., BS 2633) for the details of carrying out post weld heat treatment.

APPENDIX D – PIPE END MAGNETISM

D.1 Introduction

Excessive magnetism at the pipe ends can prevent satisfactory weld deposition. This is particularly prevalent when welding pipes in existing pipelines which have previously been cleaned or inspected by magnetic pigs. New pipes can sometimes suffer from excessive magnetism arising from electromagnetic pipe handling equipment, or if the pipes have been stored for any period of time in a north-south orientation.

As a general rule, the best principle is to avoid magnetising pipes (and fittings) in the first place. However, as this is not always possible, this appendix provides some guidance on methods to mitigate the effects of pipe end magnetism.

D.2 Low Levels of Magnetism

Low levels of magnetism (less than 50 Gauss) can be simply defined as there being sufficient force to hold a paper clip to the pipe end. No precautions are usually needed for welding.

D.3 Medium Levels of Magnetism

At medium levels of magnetism (50 – 120 Gauss), there is sufficient magnetism to hold a large diameter welding rod to the pipe end. Under these circumstances, the easiest method of overcoming the effect is to use alternating current (AC) welding for the root, using an electrode that is suitable for the purpose. The use of AC for the root in these circumstances does not justify re-qualification of the weld procedure.

Sometimes AC is not effective at these levels and the situation must then be treated as a high level effect.

D.4 High Levels of Magnetism

High level of magnetism (over 120 Gauss) is the usual level of magnetism that is found after a pig run with a magnetic cleaning pig or the on line inspection vehicle. AC welding is usually not a satisfactory solution and de-magnetization or de-gaussing must be carried out. One such method, which is field proven, is as follows:

Step 1 – Separate all components and de-magnetize them all, if necessary, before setting up the joint. The pipe and component ends need to be not less than 300 mm apart during de-magnetization.

Step 2 – Measure the magnetic field at a number of points round the pipe, taking the readings on the root face. Keep the gaussmeter in line with the pipe and the end of the probe holder should be in gentle contact with the pipe. Identify the area where the field is at its maximum, mark the position and note the reading.

Step 3 – Wrap welding cable of 300 A minimum capacity round the pipe to give 18 to 20 turns. The edge of the coil must be 50 mm to 80 mm from the end of the pipe. Aluminium-cored cable is not recommended but can be used, if necessary, on larger diameters. Short lengths of pipe (pups) may not require a full number of turns. The amount of cable needed is as given in Table C.1.

Step 4 – Connect the coil to a welding generator and, setting a low current (less than 80 A), switch on using the polarity change switch. Observe the change in reading shown on the gauss-meter. If the reading reduces or reverses, note the position of the polarity switch. If the reading increases, reverse the polarity and check the decrease.
Note the polarity. Switch off.

Step 5 – Turn the generator controls to maximum and, using the polarity switch, turn on the current to the same polarity as noted in operation d) above. After 10 seconds switch off. The current level must drop immediately. Do not reduce current gradually.

Step 6 – Take gauss-meter reading at the point noted in operation Step-2 above and compare with original reading. If everything has been done correctly, the field should have reduced or reversed. If not, return to operation Step-2 above and repeat operations Step-2 thru' Step-5, above**.**

Step 7 – Check the reading and:

If reading after de-magnetisation is less than 50 gauss, welding is possible with dc current, and no further action is necessary.

If reading is less than 120 gauss, welding should be possible with ac current. At this stage, there is the choice of either welding with AC or carrying out the procedure in operation Step-8 below.

If reading is greater than 120 gauss, further de-magnetization is necessary as in operation Step-8 below. If polarity has reversed, return to operation Step-4 above.

Step 8 – If reading is greater than 400 gauss, repeat operations Step-5 thru Step-7 above.

If reading is between 120 gauss and 400 gauss, reduce current to 60% and repeat operation Step-5 above.

NOTE – If there has been a field reversal, the procedure should be modified so as to use opposite polarity as used in operation e) above.

Step 9 – Degauss other components where necessary prior to fitting up.

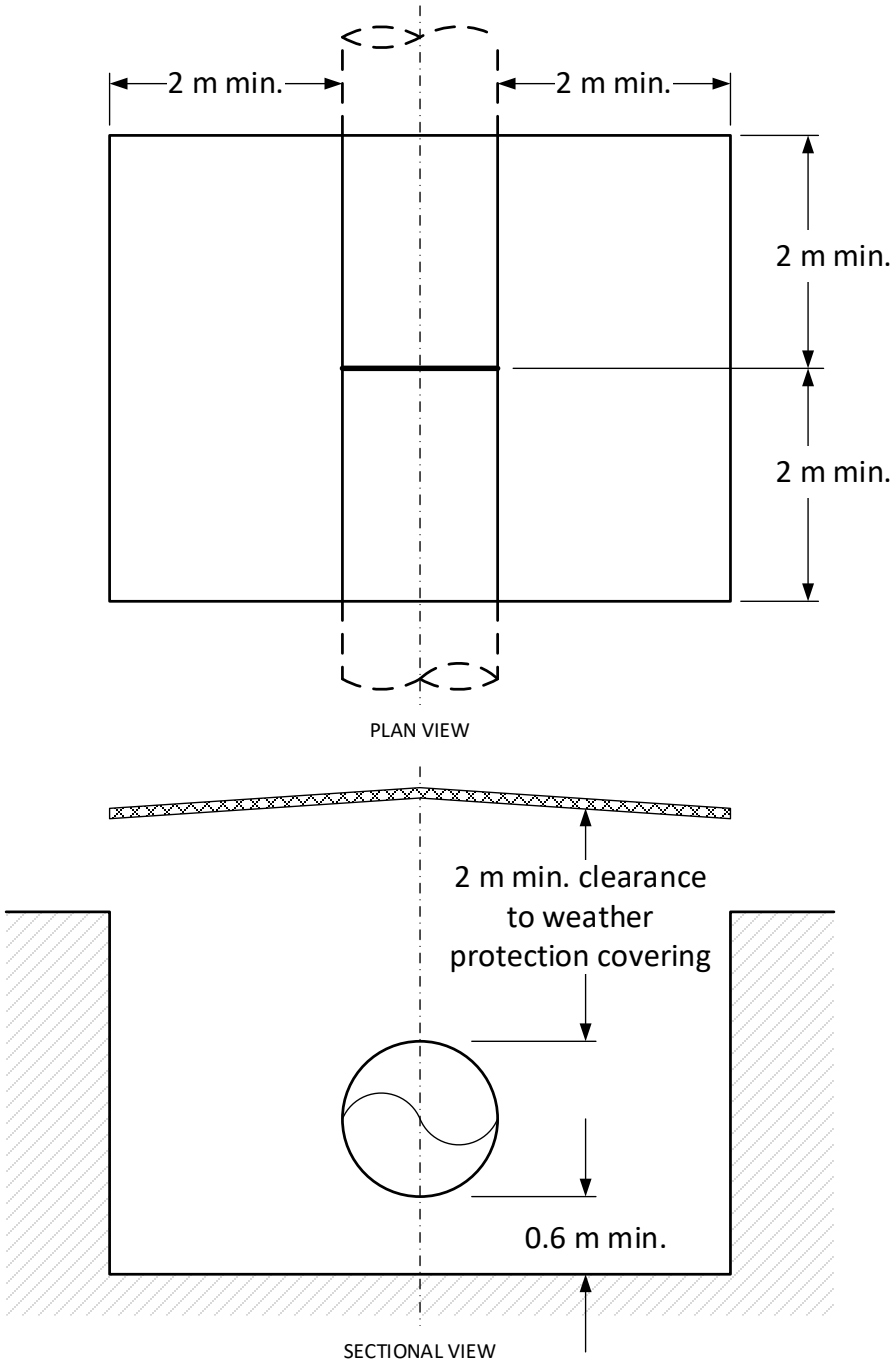
D.5 Non-Destructive Testing

Where the magnetic field still affects the welding arc, but not to the extent that the joint was unweldable, the primary volumetric inspection method shall be supplemented by another volumetric inspection method. For example, if radiographic examination was the primary volumetric inspection method, then it would be supplemented with ultrasonic testing.

Table D.1. Minimum Length of Cable Required for De-Magnetisation (De-Gaussing).

Pipe OD (mm)	Min. Length of Cable Required * (m)		Pipe OD (mm)	Min. Length of Cable Required * (m)
114.3	5		610.0	40
168.3	10		762.0	50
219.1	15		914.4	60
273.1	20		1067.0	70
323.9	25		1219.0	80
457.1	30		1422.0	90
* Cable lengths above refer only to the coils wrapped around the pipe end. Additional cable is necessary to connect the coil to the welding generators.				

APPENDIX E – BELL-HOLE EXCAVATION DETAILS



Notes:

a) Suitable access and egress facilities shall be provided.

b) Excavation/trench walls shall be stabilized.

c) Provision shall be made for removal of water from the excavation/trench.

d) Consideration shall be given to providing pipe supports for large excavations and/or when heavy equipment is mounted on the pipe.