Gas Industry Standard

GIS/P8: 2025

Specification for

Welding of Steel Onshore Natural Gas Installations Designed to Operate at Pressures Greater Than 7 Bar

Cadent
Your Gas Network

Gas Networks Ireland

national gas transmission

Northern Gas Networks

SGN

WALES&WEST UTILITIES

Contents

FOREWORD 3

MANDATORY AND NON-MANDATORY REQUIREMENTS 3

DISCLAIMER 3

BRIEF HISTORY 4

1 SCOPE 5

2 REFERENCES 6

3 DEFINITIONS 7

4 QUALITY SYSTEM 8

5 HEALTH & SAFETY REQUIREMENTS 9

6 INFORMATION & REQUIREMENTS TO BE APPROVED AND DOCUMENTED 10

7 EQUIPMENT 15

8 WELDING PROCESS 16

9 MATERIALS 17

10 ELECTRODES, FILLER MATERIALS AND SHIELDING GASES 18

11 TESTING, QUALIFICATION AND APPROVAL OF WELDING PROCEDURES 20

12 WELDERS – TESTING, QUALIFICATION AND APPROVAL 51

13 PRODUCTION WELDING 57

14 EXAMINATION AND NON-DESTRUCTIVE TESTING OF WELDS 68

15 WELD ACCEPTANCE CRITERIA 70

16 RECTIFICATION OF DEFECTIVE WELDS 73

17 RECORDS 75

APPENDIX A – REFERENCES 77

APPENDIX B – DEFINITIONS 80

APPENDIX C – GUIDANCE ON POST WELD HEAT TREATMENT 82

APPENDIX D – PIPE END MAGNETISM 83

APPENDIX E – TYPICAL BELL-HOLE EXCAVATION DETAILS 85

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

First published as BGC/PS/P8	October 1975
Withdrawn and replaced by BGES/P2	March 1994
First published as IDN/SP/P/8	February 2012
Revised and introduced into the NGN document suite as NGN/SP/P/8	July 2017
GD/SP/P/8 (Cadent Gas) T/SP/P/8 (National Grid) NGN/SP/P/8 (Northern Gas Networks) SGN/SP/W/8 (Southern/Scotia Gas Networks) T/SP/P/8 (Wales & West Utilities)	November 2018 November 2010 July 2017 September 2018 February 2012
Reviewed, updated, and published as a Gas Industry Standard	March 2025

1 SCOPE

This specification contains the requirements for the welding of carbon, carbon manganese and low alloy steels used in the construction of onshore natural gas installations designed to operate at pressures greater than 7 bar in accordance with the recommendations given in IGEM/TD/1 and IGEM/TD/13 in the UK or IS 328 in the Republic of Ireland.

The specification is applicable to the welding of:

- Pipeline off-take installations
- Pressure reduction installations
- Pipe-work skid units
- Interconnecting or diversionary pipe work within the confines of an installation
- Pipeline pigging facility sites
- Block valve installations
- Compressor stations

All welding, excluding connecting field welds of sub-assemblies and diversionary pipe work within the confines of an installation site, shall be carried out in a workshop.

This specification details requirements for the production of welded joints that meet national and international welding standards. Welds produced to this specification are considered equivalent in quality to welds produced to BS 4515-1, or to BS EN 12732 (category D) quality requirements.

Welding procedure qualification testing shall be in accordance with BS EN ISO 15614-1 Level 2, except where amended by the requirements of this specification.

In case of conflict between this specification and the codes, standards and specifications referenced in Appendix A, the requirements of this specification shall apply.

Subject to the approval of the Gas Transporter, skid unit pipework may be manufactured to an alternative national or international welding standard. If the use of an alternative welding standard is agreed by the Gas Transporter, then the manufacturer or contractor shall submit a project specific welding fabrication and inspection specification to the Gas Transporter for approval.

This specification is applicable to pipe, or fittings having a specified minimum yield strength which does not exceed 555 N/mm^2 (i.e., grade L555 or X80).

This specification is not applicable for the production of pipe work intended for the processing or transportation of sour natural gas.

This specification is not intended for the welding of carbon steel pipelines (see GIS/P2) or the in- service welding of pressurised pipe work (see GIS/P9).

2 REFERENCES

This Specification makes references to the documents listed in Appendix A. Unless otherwise specified, the latest edition of the documents apply, including all amendments.

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 DEFINITIONS

3.1 Terms and Definitions

The requirements and definitions applying to this specification are listed in Appendix B.

3.2 Abbreviations

The following abbreviations are used in this specification:

- AUT Automatic ultrasonic testing
- AWT All-weld metal tensile test
- CE Carbon equivalent value (also CEV)
- CTOD Crack tip opening displacement
- DN Nominal diameter
- DPI Dye penetrant inspection (also penetrant testing, PT)
- FBE Fusion bonded epoxy
- HAZ Heat affected zone
- HV Vickers hardness
- MMA Manual metal arc welding (also SMAW)
- MPA Manual phased array ultrasonic testing (also MPAUT)
- MPI Magnetic particle inspection (also MT)
- NDT Non-destructive testing
- OD Outside diameter
- PWHT Post weld heat treatment
- pWPS Preliminary welding procedure specification
- RT Radiographic testing
- SMYS Specified minimum yield strength
- TIG Tungsten inert gas welding (also GTAW)
- T/V Transverse direction (i.e. perpendicular to the weld)
- UT Ultrasonic testing (usually manual UT)
- WPS Welding procedure specification
- WT Nominal wall thickness (also *t*)

4 QUALITY SYSTEM

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.

4.1 Sub-Contracting

The use of a sub-contractor by a manufacturer or main works contractor shall be subject to the approval of the Gas Transporter. Any sub-contractor shall work under the order and responsibility of the manufacturer or main works contractor and shall fully comply with the relevant requirements of this specification, including BS EN ISO 3834-2 quality systems.

5 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

6 INFORMATION & REQUIREMENTS TO BE APPROVED AND DOCUMENTED

6.1 Information to be Supplied by the Gas Transporter

The manufacturer or contractor shall ensure that all information necessary to carry out the welding process to the requirements of this specification is complete and available prior to work commencing (see Table 1).

Table 1. Information to be Supplied by the Gas Transporter.

	Information	Gas Transporter Response
a)	Whether batch testing of electrodes and filler materials is required (see 10.1 in this specification).	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 10.1).	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 10.1).	For L555 (or X80) pipe material grade the deposited weld metal yield strength shall overmatch the SMYS 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 10.2).	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 11.10).	In the event of failure of any of the mechanical tests, retests may be permitted at the Gas Transporter's discretion.
f)	Whether an alternative location is permitted for the excavation location for the repair weld test.	When approved by the Gas Transporter, an alternative location for the repair excavation would be the same position on the opposite side of the joint.
h)	Whether specimens should be allowed to cool for durations other than 24 hours before testing.	Any alternative duration will be contract specific (see 11.6).
i)	The method of weld tensile testing when a minimum weld metal yield strength requirement is specified.	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.	Transverse tensile testing is not required for butt welds in pipe of outside diameter ≤ 114.3 mm OD (see 11.7.1).
k)	Whether Charpy impact tests are required for welding procedure approval of butt joints.	Charpy impact testing is required for all butt welds in pipe of outside diameter greater than 114.3 mm (see 11.7.4).
l)	The number and location of test specimens required for Charpy impact tests on pipes of diameter 114.3 mm or less.	Charpy impact testing is not required for butt welds in pipe of outside diameter 114.3 mm or less (see 11.7.4).
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 or X80.	The Gas Transporter will specify any requirements different to those specified in 11.7 on a contract specific basis.

	Information	Gas Transporter Response
n)	Whether additional NDT methods for fillet welds apply.	No additional methods are required. Borescope camera inspection may be used for pipe socket welds.
o)	Whether alternative hardness values to those given in Table 7 are required.14.1	Alternative hardness values are not required.
p)	Whether a proposed change to a welding procedure or equipment requires re-qualification of the welders.	Any other change in the welding procedure or equipment which, in the opinion of the Gas Transporter, makes production of a sound weld more difficult for the welder. The Gas Transporter shall be notified of any proposed change.
q)	Whether prevailing weather conditions are such that quality of the completed weld would be impaired.	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.	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 14.1 of this specification, and also GIS/NDT2.
s)	Whether completed welds are to be ground.	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 13.2 of this specification).
t)	Whether alternative techniques are to be used for radiographic testing of welded butt joints.	GIS/NDT2 requires radiographic testing in accordance with BS EN ISO 17636-1 Class B. An alternative technique shall not be used without the approval of the Gas Transporter.
u)	Ultrasonic testing acceptance criteria.	Table 23, as amended by clause 15 of this specification.
v)	Whether NDT acceptance criteria are to be based on quality control or engineering critical assessment.	ECA shall not be used for new-build fabrication.
w)	Whether the maximum planar defect dimension is to be less than 25 mm.	When specified by the Gas Transporter.
x)	Whether a more stringent limit for root penetration is required.	When specified by the Gas Transporter.

6.2 Items Subject to Approval by the Gas Transporter

The manufacturer or contractor shall ensure that their project Quality Plan incorporates the specific items subject to approval by the Gas Transporter (see Table 2).

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

	Item	Gas Transporter Requirement
a)	Welding consumables to be used.	Only welding consumables approved by the Gas Transporter shall 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.	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 2a) 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.	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)	The production of test welds on pipes shorter than full length.	Full pipe lengths are not required for above ground installation welding procedure qualification tests.
e)	Use of roll welding.	To be approved by the Gas Transporter.
f)	Use of a test weld for destructive testing or re-welding to the same procedure following rejection by NDT.	The Gas Transporter will decide whether a rejected test weld may be used for destructive testing. If the rejection 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.	In the event of failure of any of the mechanical tests, retests may be permitted at the Gas Transporter's discretion.
h)	Welding procedure qualification test details and welding procedure specification for production welding.	The WPQR and WPS shall be approved by the Gas Transporter prior to production welding commencing.
i)	Any deviations from the material grouping range given in PD CEN ISO / TR 15608.	The Gas Transporter shall review and approve any proposed deviation. Consideration shall be given to the potential for any deviation to produce an adverse effect on the integrity of the welded joint.

	Item	Gas Transporter Requirement
j)	Simulation of a fillet weld joint using flat plate fillet welds.	Simulation plate fillet welds are permitted.
k)	Alternative methods of NDT for welder test pieces.	With the prior approval of the Gas Transporter, butt weld tests may be examined using manual phased array ultrasonic testing.
l)	Giving a welder a second opportunity to gain approval.	The Gas Transporter may agree to a second test attempt, where it can be demonstrated that the reason for failure was beyond the welders' control.
m)	All documentation relating to welder qualification tests.	Records shall be kept for the period of validity. A welder's qualification will remain valid for the period stated, subject to continued satisfactory performance and prolongation.
n)	Use of manual thermal cutting for pipe end bevelling and the ability of the operator.	Not permitted.
o)	The blending out by grinding of minor imperfections within the joint preparation area.	At the Gas Transporter's discretion in each case.
p)	Method of marking datum points on a joint for ultrasonic testing.	Marking is not required for welds examined using MPA ultrasonic methods. For AUT see GIS/NDT2.
q)	Method of obtaining minimum mis-alignment other than rotation of the pipes.	The manufacturer or contractor shall submit a method statement for the Gas Transporter's approval, detailing how excessive pipe misalignment will be corrected.
r)	Method of alignment of pipes other than internal line-up clamps.	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 clause 13.6 of this specification
t)	The stage at which support is removed for pipe or fittings.	All pipe and fittings shall be fully supported throughout the welding cycle (see clause 13.6 of this specification).
u)	Repair of places where stray arcs have occurred.	See clause 13.12 of this specification.
v)	Means of applying preheat.	To be approved by the Gas Transporter prior to use (see clause 13.13.1).
w)	Methods of attaching and removing thermocouples.	The methods to be used shall be submitted to the Gas Transporter for approval prior to use.
x)	The design of branch connections.	All branches shall be made with specialised fittings e.g., forged or pressed tees, forged set-in or set-on fittings.

	Item	Gas Transporter Requirement
y)	Written ultrasonic examination procedure for pipe material around planned cut out.	For cut pipe ends and pipe areas for welded attachments - See GIS/NDT2. A written procedure shall be submitted to the Gas Transporter for approval prior to commencing.
z)	The NDT procedures to be used for inspection and testing.	See Table 22.
aa)	All inspection personnel.	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.
bb)	The technique in BS EN ISO 17636-1 to be used for radiographic examination.	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.	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.	Not applicable to GIS/P8.
ee)	Any proposal to repair a weld.	Repairs are permitted within the limits stated in clause 15 and 16 of this specification.
ff)	Any alternative limits on repair weld length.	Not permitted without the Gas Transporter's approval.
gg)	Use of root sealing or single run repair deposits.	Single pass root bead remedial welding is only permitted for mechanised welding systems that utilise internal welding heads.
hh)	More than one attempt at repair.	Multiple attempts to repair a weld are not permitted unless specifically approved by the Gas Transporter (see 16.3 and 11.7.10).
ii)	The use of sub-contractors.	To be approved by the Gas Transporter.

7 EQUIPMENT

Welding equipment shall be suitable for the welding process employed and be calibrated and maintained in a condition that allows production of acceptable welds, continuity of operation, and the safety of personnel.

Arc welding equipment shall be capable of operating and controlling the welding parameters detailed in Table 12 within the limits stated in the approved WPS sheet. Equipment that does not meet this requirement shall either be repaired or replaced. The relevant standard for calibration, validation, and consistency testing of arc welding equipment is BS EN IEC 60974-14.

The manufacturer or 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 Transporters Inspector for monitoring purposes when requested.

Note: Copper contact tips and backing strips, when used, should be checked regularly for damage which could indicate copper contamination of welds.

Pipe handling equipment, rotators, rollers and line-up clamps shall be such that they avoid damage to the pipe and fittings, ensure that axes are aligned in accordance with 13.5 and Table 19 and allow the unhindered application of the welding procedure.

8 WELDING PROCESS

This specification covers the following manual, semi-automatic or mechanised welding processes:

111 Manual Metal Arc welding (MMA, or SMAW)

121 Submerged Arc welding with solid wire electrode, partly mechanized (SAW)

125 Submerged Arc welding with tubular-cored electrode, partly mechanized (SAW)

131 Metal Inert Gas welding with solid wire electrode (MIG)

135 Metal Active Gas welding with solid wire electrode (MAG)

136 Metal Active Gas welding with flux-cored electrode (GS-FCAW)

138 Metal Active Gas welding with metal-cored electrode

141 Tungsten Inert Gas welding with solid electrode (TIG)

Self-shielded tubular cored metal arc welding (114) is not permitted.

Note: Welding process numbering is taken from BS EN ISO 4063.

8.1 Welding Process and Welding System Approval

When required by the Gas Transporter, the manufacturer or 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.

The extent of any welding process or welding system consistency trials shall be agreed between the manufacturer or contractor and the Gas Transporter. This should preferably be agreed at tender or contract award stage 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.

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

All consistency trial test welds shall be subject to full non-destructive testing in accordance with GIS/NDT2 and shall meet the requirements of Table 23 of this specification.

All consistency trial and welding procedure qualification test welds shall be subject to the destructive tests specified in section 11 of this specification and in the event of specimen failure, any additional tests required by the Gas Transporter. The number of CTOD test specimens, when required, will be specified by the Gas Transporter, or shall be agreed between the Gas Transporter and the manufacturer or contractor prior to welding commencing.

9 MATERIALS

This specification is applicable to pipe, or fittings having a specified minimum yield strength which does not exceed 555 N/mm^2 (i.e., grade L555 or X80). All pipe, fittings and attachments shall comply with the Gas Transporter specifications listed in Table 3. Should the Gas Transporter approve the use of alternative pipe or fittings not manufactured in accordance with the specifications given in Table 3, the design of the pipe or fitting shall be fully compliant with Gas Transporter design requirements and the mechanical and chemical properties of the pipe or fitting should comply with the applicable specification listed in Table 3.

The International Institute of Welding (IIW) empirical formula shall be used when calculating carbon equivalent values. Heat/cast analyses shall be used.

$$CE_{IIW} = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Cu + Ni)}{15} \quad [values\ in\ weight\ percent]$$

Table 3. Material Specifications.

Items to be Welded	**Relevant Specification(s)**
Pipe	T/SP/PIP1 GIS/L3
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
Note: Contractor shall verify with the Gas Transporter which Gas Transporter specifications/GIS Documents are adopted by the relevant Gas Transporter.	

10 ELECTRODES, FILLER MATERIALS AND SHIELDING GASES

10.1 General

Welding consumables shall be approved by the Gas Transporter before use (see 6.2 item (a)) and shall be in accordance with the classification standard applicable to the proposed welding process (see Table 4).

The chemical composition of the deposited weld metal shall be compatible with the materials being welded.

When tested in accordance with clause 11.7.1, the weld metal produced by any of the above welding processes or combination of these processes, shall have a tensile strength greater than the parent material. Excessive overmatching of strength shall be avoided.

The weld metal tensile strength of joints between dissimilar materials, when tested in accordance with clause 11.7.2, shall meet the specified minimum tensile strength of the higher strength parent material.

When tested in accordance with clause 11.7.1, the weld metal yield strength of welds in pipe material of L555 or X80 grades shall overmatch the SMYS by at least 5%.

When baking of electrodes is required in order to achieve a given level of diffusible hydrogen, the electrode manufacturers' recommendations shall be followed. Vacuum packed electrodes shall be used in accordance with the manufacturers' instructions.

Welding electrodes or consumables achieving the low hydrogen requirements of Scale D, as defined by BS EN 1011 Part 2, shall be used to weld all un-pupped fittings equal to or greater than 762 mm pipe diameter.

Cellulosic covered electrodes shall not be used for the welding of pipes or fittings which have a carbon equivalent value in excess of 0.43%.

Cellulosic covered electrodes shall not be used for the welding of fillet welds.

Limitations apply to the use of Cellulosic coated electrodes to weld L555 or X80 pipe grades and fittings with an outside diameter equal to greater than 762 mm (see Table 2).

Self-shielding (i.e., 'gas-less') flux-cored arc welding consumables are not permitted.

When submerged-arc welding wire and flux combinations are proposed for use they shall, as a minimum, achieve the low hydrogen requirements of Scale C, as defined by BS EN 1011 Part 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 17174 BS EN ISO 26304

10.2 Storage and Handling

All consumables shall be identified by type, classification, and individual batch number. Different grades and types of welding electrodes and welding consumables shall be stored separately and clearly identified.

The manufacturer or contractor shall produce a welding consumable storage and handling procedure for approval by the Gas Transporter. In addition to the requirements of the storage recommendations provided by the consumable manufacturer, any special measures identified by the contractor for the storage, handling and, when applicable, the use of welding consumables in the field (e.g., vacuum packaging of electrodes at a location other than the manufacturers factory) shall be fully described in this procedure.

At the discretion of the Gas Transporter, the manufacturer or contractor shall 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. Welding consumables that show sign of damage or deterioration shall not be used.

Submerged-arc welding flux shall only be recycled or re-dried in accordance with the flux manufacturer's recommendations. The welding contractor, or subcontractor, shall produce a method statement for approval by the Gas Transporter.

10.3 Shielding Gases

10.3.1 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 shall require requalification of the weld procedure.

10.3.2 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.

Mixing of gases may be permitted in a workshop provided the equipment is proven to be suitable for the application and the mix can be verified through testing and/or calibration.

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.

11 TESTING, QUALIFICATION AND APPROVAL OF WELDING PROCEDURES

11.1 General

All testing qualification and approval of welding procedures shall be in accordance with BS EN ISO 15614-1 Level 2, and Section 11 of this specification.

A preliminary welding procedure specification (pWPS) shall be prepared in accordance with BS EN ISO 15609-1 and shall meet the requirements of this specification.

All new weld procedure qualification tests shall include bend tests, in accordance with BS EN ISO 15614-1.

In case of conflict between this specification and BS EN ISO 15614-1, the requirements of this specification shall apply. The welding and testing of all procedure qualification test joints shall be witnessed by the Gas Transporter or the Gas Transporter's representative, who shall also approve the final documentation packages as detailed in Section 17.

Note for Guidance: BS EN ISO 15607 provides a flow diagram for the development and qualification of a WPS.

11.2 Previously Qualified Welding Procedures

Where a manufacturer or contractor proposes the use of a previously qualified welding procedure, that remains valid within the changes affecting approval given in BS EN ISO 15614-1 and Table 12 of this specification it shall be offered for the Gas Transporter's consideration at the earliest opportunity, ideally at project tender or contract award stage. The approval or use of a previously qualified welding procedure will be at the sole discretion of the Gas Transporter.

Previously qualified welding procedures where bend testing has not been carried out may be offered for the Gas Transporter's consideration.

Previously qualified welding procedures will not be considered where one or both of the pipe materials joined are L555 (or X80) grade or an equivalent material.

Previously qualified welding procedures will not be considered if they have not been in regular use in the preceding ten years.

11.3 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.

11.4 Materials

New welding procedure qualification tests should 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 grouping of materials as specified in ISO/TR 15608 may be applied to qualified welding procedures (see Table 14) and the subsequent range of approval for this grouping system as defined in BS EN ISO 15614-1. Separate welding procedure qualifications are required for each parent material or combinations of parent material not covered by the grouping system.

Note: The groupings specified in Table 14 do not imply that base materials or filler metals of different analyses within a group may be indiscriminately substituted for a material that was used in the qualification test without consideration of the compatibility of the base materials and filler metals from the standpoint of metallurgical and mechanical properties and requirements for pre- and post-heat treatment.

When the pWPS proposes the application of PWHT of the completed weld, the possible detrimental effects of PWHT on the parent metal properties of pipes and fittings shall be fully considered prior to proceeding with weld procedure qualification testing.

When a welding procedure will be used on existing installation material, confirmation of the 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 appropriate material sampling procedure, such as GIS/Q10.

The length of any pipe or pipe pup used for procedure qualification shall be agreed with the Gas Transporter prior to welding and should be of suitable size to allow simulation of production welding conditions and to accommodate the required mechanical test specimens. The minimum individual pup length permitted is 150 mm.

11.5 Preparation, Set-up, and Welding of Procedure Test Welds

11.5.1 Preparation and Set-Up

The procedure test weld shall be prepared and set-up in accordance with the requirements of BS EN ISO 15614-1, the approved pWPS and clause 13 of this specification.

The qualification of all welding procedures shall simulate the intended production application. If it is intended that tack welds are to form part of the final joint, then they shall be included in the test piece and be of typical length and spacing as those to be used during production welding. 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 (see clause 7).

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

11.5.2 Welding of Test Welds

The procedure test weld shall be welded in accordance with the requirements of BS EN ISO 15614-1, the agreed pWPS and clause 13 of this specification.

The procedure test weld(s) for semi-automatic or mechanised welding systems shall qualify the minimum and maximum welding parameter range to be used. Should the proposed limits of the welding parameter range need to be more tightly controlled or be outside the tolerances permitted by BS EN ISO 15614-1 and Table 12 of this specification, the limits of the range shall be agreed between Gas Transporter and the manufacturer or contractor prior to welding commencing (see also 11.11).

The manufacturer or contractor shall produce a sufficient number of test welds to fully qualify the proposed welding process or procedure in accordance with this specification.

When a qualified welding procedure is intended to be used outside the workshop environment, a minimum of two welders shall be used to weld pipe or fittings with outside diameter greater than or equal to 406.4 mm.

Roll welding is defined as welding in the downhand (PA) position with pipe rotation achieved by rolling it on wooden sleepers, or trestles. This method shall only be permitted by the approval of the Gas Transporter.

The use of positioners and pipe rotators shall be subject to agreement by the Gas Transporter. The intended welding position/direction(s) shall be demonstrated by procedure qualification testing.

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

Where production conditions are such that pipe-to-pipe joints cannot be completed in one welding heat cycle, the welding of the procedure test welds shall simulate the number of heat cycles where the joint has been allowed to cool to ambient temperature before completion. This thermal cycle will then be considered to form part of the qualified range of approval.

Minimum preheat and weld inter-pass temperatures used in the qualification of a welding procedure test weld shall be in accordance with Table 21 of this specification. The actual minimum and maximum preheat and weld inter-pass temperatures attained during the welding of the test joint shall be measured and recorded on the welding procedure qualification record sheet. The subsequent minimum and maximum pre-heat and interpass temperatures used during production will be those recorded during the approval test.

When the qualified welding procedure is intended to cover a range of thicknesses, it may be necessary to complete the cap with a split or multi run cap rather than a single weave cap. For such cases, the welding procedure qualification shall cover both capping options and include appropriate testing as required on each.

The qualification test welding of branch set-on fittings (e.g., weldolets) and branch set-in fittings (e.g., sweepolets) procedure test welds shall be in accordance with the agreed pWPS and clause 13. Note that the Gas Transporter specification GIS/PW11 Part 1 limits the maximum size of a set-on fitting to 88.9 mm OD.

Note: Branch set-on fittings such as weldolets, threadolets, and sockolets are attached to the carrier pipe using full penetration butt welds.

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.

11.6 Examination and Testing of Procedure Test Welds

The extent of examination and testing of a procedure test weld shall be in accordance with Table 5 and Figure 1 to Figure 9 of this specification. The NDT examination techniques used shall be in accordance with GIS/NDT2.

Table 5. Examination and Destructive Testing of Weld Procedure Qualification Test Welds (Based on Table 1 of BS EN ISO 15614-1).

Test Piece	Type of Inspection and Testing	Extent of Testing	Footnote
Full penetration butt welds	Visual inspection	100%	a)
	Radiography or ultrasonic testing	100%	b) and j)
	Surface crack detection (MPI)	100%	a) and c)
	Transverse tensile test	2 specimens	d)
	Bend tests	4 specimens	d)
	Charpy impact test	4 sets	e) and d)
	Macroscopic examination	3 specimens	k)
	Hardness test	3 specimens	—
	All-weld tensile test	2 specimens	f)
	CTOD test	2 sets	g)
Set-on branch attachment with full penetration butt weld (e.g., weldolet)	Visual inspection	100%	—
	Surface crack detection (MPI)	100%	c)
	Macroscopic examination	2 specimens	i)
	Hardness test	2 specimens	—
Set-in branch attachment with full penetration butt weld (e.g., sweepolet)	Visual inspection	100%	a)
	Radiography or ultrasonic testing	100%	b)
	Surface crack detection (MPI)	100%	a) and c)
	Transverse tensile test	2 specimens	—
	Charpy impact test	4 sets	e)
	Macroscopic examination	2 specimens	—
	Hardness test	2 specimens	—
Fillet welds	Visual	100%	—
	Surface crack detection (MPI)	100%	c) and i)
	Fracture test	1 or 2 specimens	h) and i)
	Macroscopic examination	2 specimens	i)
	Hardness test	2 specimens	—

a) Visual inspection and Surface crack detection to include internal ‘root’ whenever possible.

b) Ultrasonic testing shall not be used when thickness, t < 8 mm, unless specifically approved by the Gas Transporter.

c) Magnetic particle testing in accordance with GIS/NDT2.

d) Not required for full penetration butt welds ≤ 114.3 mm OD.

e) Specific requirements for the number and location of impact tests are given in clause 11.7.4.

f) When required by the Gas Transporter. Specific requirements for all-weld tensiles are given in clause 11.7.2.

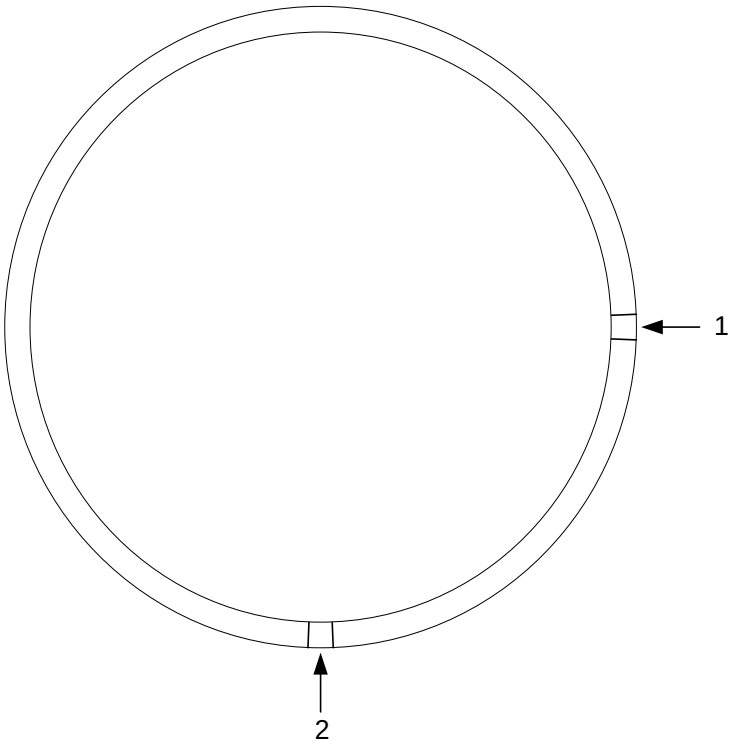
g) When required by the Gas Transporter. Specific requirements for CTOD tests are given in GIS/P2.

h) Specific requirements for fracture tests are given in clause 11.9.

i) The tests detailed do not provide information on the mechanical properties of the joint. Where these properties are relevant to the application, an additional qualification shall also be required, e.g., a butt weld qualification.

j) For pipe sizes ≤ 60.3 mm ultrasonic testing is not permitted. For pipe sizes > 60.3 mm the method of NDT shall be agreed with the Gas Transporter.

k) Only 2 macroscopic examination specimens are required for full penetration butt welds ≤ 114.3 mm OD.



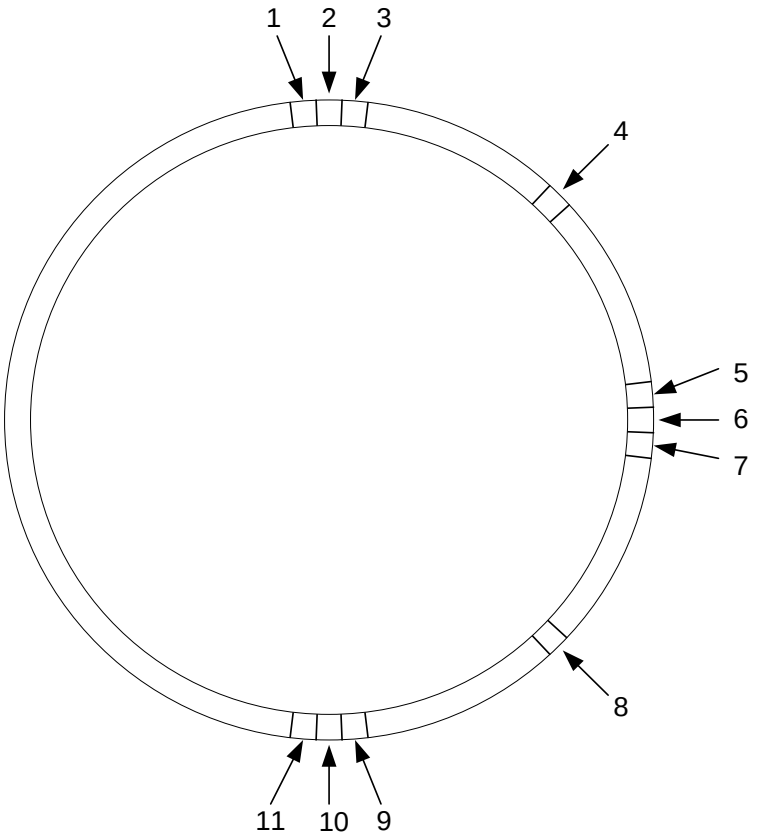
Specimen Location	Position	Mechanical Test
1	90º	Macro examination and Hardness test
2	180º	Macro examination and Hardness test

Notes:

a) The hardness survey is made on the macro-section.

b) A photograph is required of each macro-section (see 11.7.3)

Figure 1. Locations for Test Specimens for Butt Welds ≤ 114.3 mm OD.



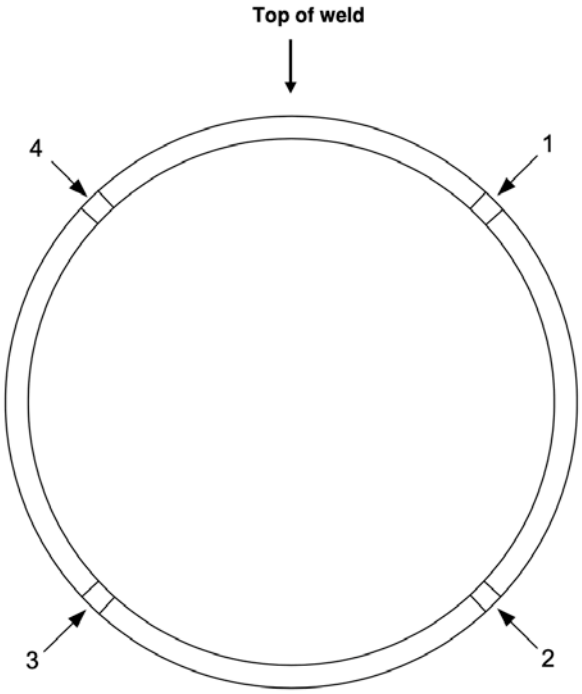
Specimen Location	Position	Mechanical Test
1	0°	Set of Charpy impact tests, weld metal centre line
2	0°	Macro examination and hardness
3	0°	Set of Charpy impact tests, fusion line pipe side
4	Typically 45°	Transverse tensile test and Bend tests (x2)
5	90°	Set of Charpy impact tests, weld metal centre line [a, b]
6	90°	Macro examination and hardness
7	90°	Set of Charpy impact tests, fusion line pipe side [a, b]
8	Typically 135°	Transverse tensile test and Bend tests (x2)
9	180°	Set of Charpy impact tests, weld metal centre line [a, b]
10	180°	Macro examination and hardness
11	180°	Set of Charpy impact tests, fusion line pipe side [a, b]

Notes:

a) The location for removal of specimens is dependent on welding direction (see 11.7.4.2).

b) When the pipe wall thickness exceeds 20 mm, or combined welding processes or welding directions are used, additional Charpy impact test sets are required (see 11.7.4.2).

Figure 2. Locations for Test Specimens for Butt Welds > 114.3 mm OD.



Specimen Location	Position	Mechanical Test
1	45°	All-weld tensile
2	Typically 135°	Set of weld metal Charpy impacts
3	225º	All-weld tensile
4	Pipe weld seam	Macro examination and hardness

Notes:

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

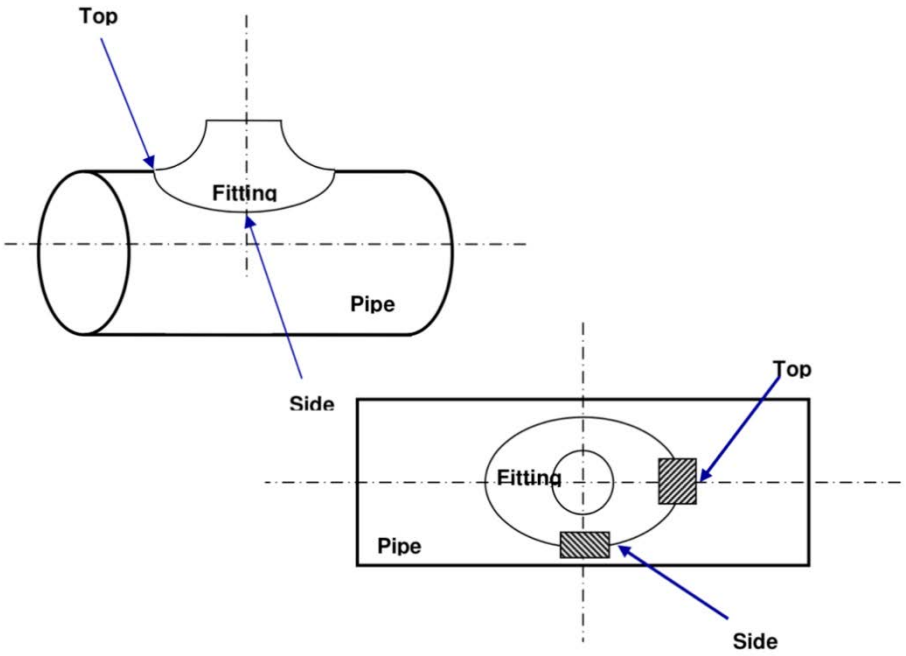
b) The all-weld tensile test specimens are only required when specified by the Gas Transporter and shall be taken from as high up in the weld body as practicably possible without compromising specimen size.

c) The hardness survey is made on the macro-specimen.

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

e) Unless specified otherwise by the Gas Transporter, specimens from location 4 will only be required for L555 (or X80) grade pipe joints.

Figure 3. Location of Additional Test Specimens for Butt Welds Made with a Mechanised Welding Process.



No.	Location	Mechanical Test
1	Top	Macro examination and hardness
2		Set of Charpy impact tests, weld metal centre line [a]
3		Set of Charpy impact tests fusion line pipe side [a]
4		Set of Charpy impact tests fusion line fitting side [a]
5		Transverse Tensile [b]
6	Side	Macro examination and hardness
7		Set of Charpy impact tests, weld metal centre line [a]
8		Set of Charpy impact tests fusion line pipe side [a]
9		Set of Charpy impact tests fusion line fitting side [a]
10		Transverse Tensile [b]
11		All-weld metal tensile [c]

Notes:

a) When the pipe wall thickness exceeds 20 mm, or combined welding processes or welding directions are used, additional Charpy impact test sets are required (see 11.7.4.2).

b) Due to fitting geometry, it may be necessary to employ reduced section tensile specimens.

c) When required by the Gas Transporter (i.e., for fitting material of 555 N/mm^2 SMYS), an all-weld metal tensile specimen (taken from a convenient side location of the fitting weld) shall be tested in accordance with 11.7.2.

Figure 4. Location of Test Specimens for Forged Set-In Branch Connections.

All test welds not subject to PWHT shall have a delay of at least 24 hours from completion of welding to commencement of final non-destructive testing. If the Gas Transporter requires an alternative delay prior to NDT this shall be agreed with the manufacturer or contractor prior to welding the test joint (see clause 14.3). Note that the manufacturer or contractor may decide to carry out additional provisional NDT examination of a weld (for quality control purposes) prior to the final NDT.

In order to be deemed acceptable, welding procedure test welds shall meet the defect acceptance criteria specified in Table 23 (see also Table 2 item f) and the destructive test requirements of Section 11.

Due to the geometry of a typical set-on fitting, limited mechanical tests can be obtained from the test weld. When required by the Gas Transporter a butt weld test, using the same welding consumables and parameters shall be qualified on equivalent materials in the form of a full penetration butt weld to provide further information with respect to the joint impact and tensile and other mechanical properties as required.

When the qualified welding procedure is intended to cover single woven and split or multi-pass capping options, both types shall be replicated on the qualification test weld. The intended primary method of weld capping will be tested as part of the original procedure qualification test. To test the alternative capping method, two additional macro specimens shall be removed from the weld, one taken from the area of highest heat input and one taken from the area of lowest heat input. Both macro specimens shall be hardness tested (see clause 11.7.3 and 11.7.5).

11.7 Destructive Testing of Procedure Butt Welds

11.7.1 Transverse Tensile Test

The preparation and testing of transverse tensile specimens for butt joints shall be in accordance with BS EN ISO 4136.

For pipes greater than 114.3 mm OD, the weld reinforcement shall be removed on both faces to give the test specimen a thickness equal to the wall thickness of the pipe.

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

11.7.1.1 Transverse Tensile Test Requirement

The tensile strength of the test specimen shall not be less than the corresponding specified minimum value for the parent metal.

The tensile strength of the weld, including the fusion zone of each specimen, shall be equal to or greater than the minimum value specified for the parent metal. Samples that fail in the weld during testing are acceptable providing the minimum value specified for the parent metal is obtained.

For dissimilar parent metal joints, the tensile strength of the parent metal shall not be less than the minimum value specified for the parent metal having the lower tensile strength.

For dissimilar parent metal joints, where the specimen fails in the weld, the tensile strength recorded shall not be less than the minimum value specified for the parent metal having the higher tensile strength (see Table 2 item c of this specification).

11.7.2 All-Weld Tensile Testing

When required by the Gas Transporter, two all-weld tensile specimens shall be prepared and tested in accordance with BS EN ISO 5178 and BS EN ISO 6892-1. All-weld tensile testing will typically be required to evaluate welding process consistency trial welds, to qualify flux-cored wire welding procedures, or when CTOD tests are specified by the Gas Transporter.

11.7.2.1 All-Weld Tensile Testing Requirements

The weld metal yield strength for L555 (or X80) grade material shall overmatch the nominal specified yield strength of the parent material by at least 5%.

11.7.3 Macroscopic Examination

Macro-examination shall be in accordance with BS EN ISO 17639. The specimens shall be prepared, polished, and etched on one side to clearly reveal the fusion line, the HAZ and the weld deposition sequence.

Macro specimens shall be taken from the applicable locations shown in Figure 1 to Figure 4. All specimens shall be hardness tested in accordance with clause 11.7.5.

All macro test specimens shall be examined at a magnification of x5. High quality photographs of each macro specimen showing the location of the hardness impressions shall be provided with the mechanical test records. The degree of photographic magnification of the specimens shown on the test report shall be accurately recorded or be indicated by the presence of a scale marker.

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. Where there are two seam welds junctions, the specimen shall be removed from the side of the joint with the highest carbon equivalent percentage.

11.7.3.1 Macro Test Requirements

The macro specimens shall be free of cracks or lack of fusion. Any other defects revealed shall be within the limits specified in Table 23.

11.7.4 Impact Toughness Testing

11.7.4.1 General

Charpy impact testing is required for all butt welds in pipe of outside diameter greater than 114.3 mm.

Charpy impact testing shall be carried out in accordance with BS EN ISO 148-1 using a striker with a 2 mm radius and V-notched specimens. The axis of the notch shall be perpendicular to the pipe surface, i.e., through-thickness.

The notch locations shall be as defined in BS EN ISO 9016, namely:

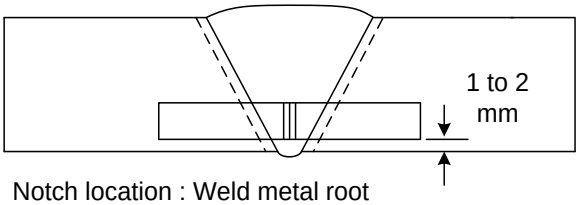
- Weld metal impacts – VWT0
- HAZ impacts – VHT0

The location of the specimens relative to the test weld is specified in clause 11.7.4.2.

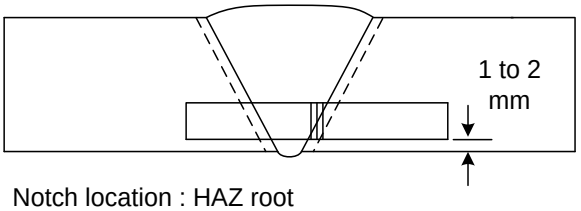
Each impact test set shall comprise three individual test specimens.

For dissimilar welds (e.g., pipe-to-fitting welds), impact tests shall be carried out on the HAZ of each parent metal.

Charpy impact test sizes and test temperatures shall be accurately recorded on the mechanical test reports.

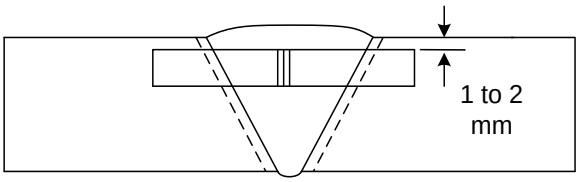


Notch location : Weld metal root

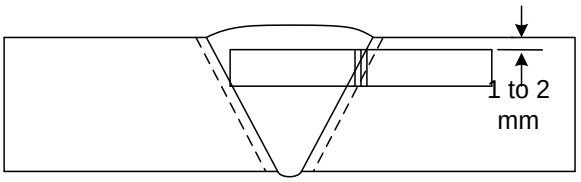


Notch location : HAZ root

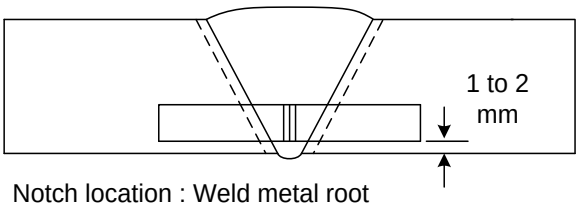
a) Wall Thickness less than or equal to 20mm



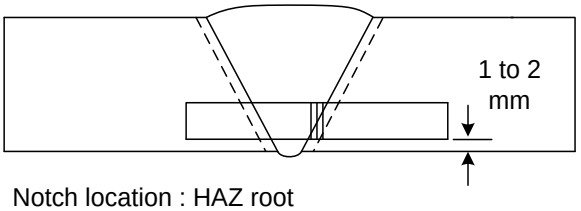
Notch location : Weld metal



Notch location : HAZ



Notch location : Weld metal root



Notch location : HAZ root

b) Wall Thickness greater than 20mm

Figure 5. Location of Notch for Charpy Test Specimens.

11.7.4.2 Specimen Location

The locations for the removal of Charpy impact test specimens is dependent on welding direction (see Figure 1 to Figure 4).

Specimens with a V-notch in the through-thickness direction shall be used. They shall be taken from within 1 mm to 2 mm above the inner surface of the parent metal and shall be transverse to the weld (see Figure 5 a).

When the majority of welding is in the vertical up direction the test specimens shall be taken from the 3 o'clock position. When the majority of welding is in the vertical down direction the test specimens shall be taken from the 6 o'clock position.

For thicknesses > 20 mm, two additional sets of specimens shall be taken, one from weld metal and one from the HAZ, taken within 1 mm to 2 mm below the outer surface of the parent metal and transverse to the weld (see Figure 5 b).

Except for welding procedures where the root pass is welded vertical-up and the remainder of the passes are welded in the vertical-down direction, welding procedures using a combination of welding directions and/or welding processes in joints of greater than 15.9 mm nominal wall thickness require two additional sets of impact test specimens to be taken. These will be as per Figure 5b. One specimen shall be taken from the weld metal centre and one from the HAZ (unless testing of both sides is required as stated in clause 11.7.4.1). The samples shall be taken from between 1 mm and 2 mm from the outer surface of the parent metal.

When the volume of deposited weld metal in different directions is approximately equal, the root impact specimens shall be taken from the appropriate position corresponding with the direction of the majority of welding in the lower half of the joint. The additional cap impact specimens shall be taken from the position that corresponds with the direction of the majority of welding in the upper half of the joint.

11.7.4.3 Impact Test Temperature

The impact test temperature is a function of design and shall be specified by the installation designer or design authority, but generally considered to be the minimum design temperature.

Where tying into legacy pipework the design authority is responsible for proposing a practical impact test temperature and carry out the risk assessment. This is to address the achievable properties of the legacy pipe material to be welded.

For new build construction a test temperature of minus 20°C may be suitable.

11.7.4.4 Absorbed Energy Requirements

When at the minimum design temperature, the absorbed energy requirements for Charpy impact tests are given in Table 6 of this specification.

Table 6. 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 to < 10 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.

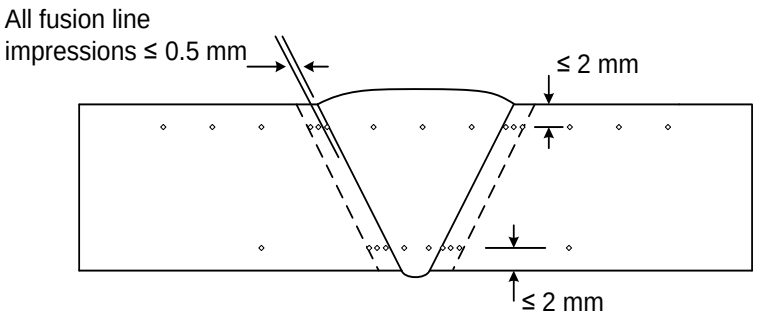
d) The sub-sized specimen impact requirements apply only to materials with SMYS ≤ 450 N/mm^2.

11.7.5 Hardness Testing

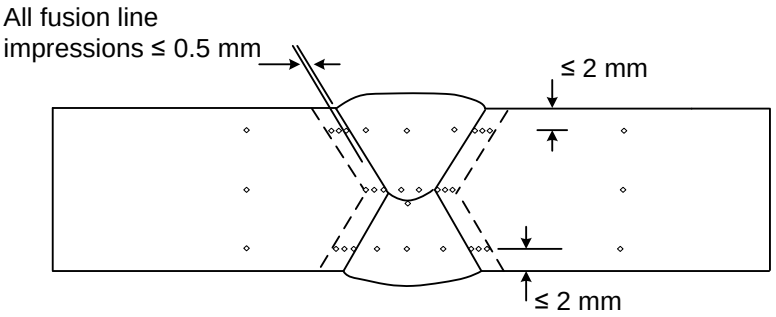
Hardness testing is required on all macro specimens. Vickers hardness testing as per BS EN ISO 6507-1 with a load of 10 kg (HV_{10}) shall be performed in accordance with BS EN ISO 9015. Hardness measurements shall be taken to sample the parent material on both sides of the weld joint, the weld metal, and the heat affected zone on both sides of the weld, to evaluate the range of hardness values across the welded joint. The hardness survey shall include two rows of indentations made at a depth of up to 2 mm below the upper and lower surfaces of the welded joint (see Figure 6). For double-sided welds or internal weld repairs one additional row of indentations shall be made through the root area (see Figure 6).

Each row of the hardness survey shall have at least one individual indentation in both parent metals and three individual indentations in both heat affected zones and in the weld metal. The first indentation in each HAZ shall be placed as close to the fusion line as possible (see Figure 6a).

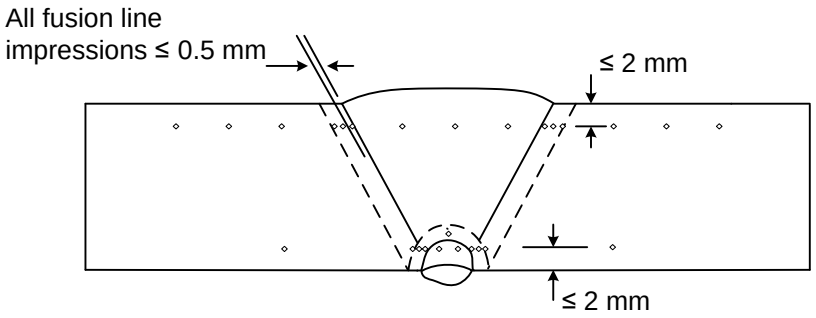
Due to the narrow HAZ in some welds made by mechanised processes it may be necessary to carry out hardness testing using a 5 kg load (HV_5). In such cases this shall be clearly indicated in the test house report.



a) Location of Hardness Indents for a Single-Sided Butt Weld.



b) Location of Hardness Indents for a Double-Sided Butt Weld.



c) Location of Hardness Indents for an Internal Root Repair.

Figure 6 Location of Hardness Surveys for a Butt Weld.

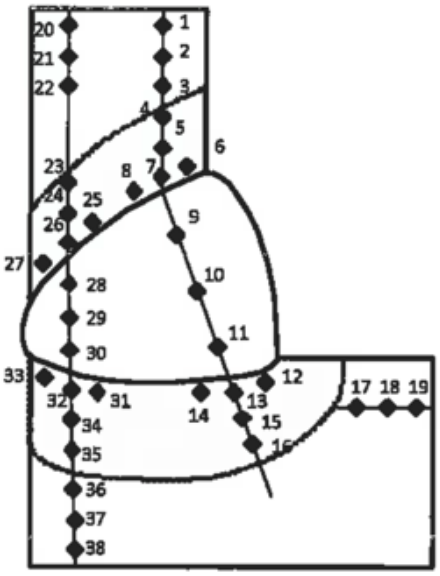


Figure 7 Locations of Hardness Survey Indents for a Set-on Branch Fitting.

11.7.5.1 Hardness Test Requirements

The results of the hardness test shall meet the requirements of Table 7.

Table 7. Hardness Limits.

	Maximum Allowable Hardness (HV_{10})	
	Weld Metal	**Heat Affected Zone**
Manual Metal Arc Welding with Cellulosic Coated Electrodes	275	275 (root) 325 (cap)
Manual, Semi-Automatic, or Mechanised Welding Using Hydrogen Controlled Electrodes or Filler Metal	275 (b)	350
Note: a) Sour service applications are not covered in this specification. b) For pipe grade L555 (or X80) the maximum permitted weld hardness shall be 300 HV_{10}.		

11.7.6 Additional Tests Required for Information Purposes

11.7.6.1 General

When required to meet particular project requirements or to provide necessary information on specific welding processes or welding systems, the Gas Transporter may specify that additional mechanical test specimens be removed and tested from procedure test welds.

11.7.6.2 Consumable Batch Testing Comparison Test

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 Figure 5) shall be taken from the approximate location shown in Figure 3 of this specification and tested at minus 20°C or other agreed temperature. 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.

11.7.6.3 Material Toughness Testing for Fracture Mechanics Calculations

These tests, which may be required to provide data for fracture mechanics calculations, include CTOD and/or all-weld tensile tests. CTOD testing when required shall be undertaken as specified in GIS/P2.

When required for procedure qualification, the Gas Transporter will specify the CTOD and AWT acceptance or re-testing criteria.

11.7.7 Forged Set-On Branch Attachments

The destructive tests required when qualifying a small diameter (15 mm to 80 mm nominal OD) branch attachment welding procedure, (e.g., a weld-o-let fitting) shall consist of two macro sections taken at 90º to each other (the specimens shall be taken from the top and side of the weld).

A hardness survey is required on both macro sections in accordance with clause 11.7.5 (Figure 7).

11.7.8 Welding of Remedial and Repair Procedure Test Welds

11.7.8.1 Remedial Welding Procedure Qualification

Remedial welding carried out to the joint during the original weld heat cycle only requires procedure qualification testing when the pWPS contains changes that affect the essential variables of the original joint WPS (see Table 12). Providing the remedial welding parameters used fall within the ranges of the WPS qualified by the approval test then separate or additional testing is not required.

Qualification of a single pass root bead remedial procedure is only permitted for mechanised welding systems that use internal welding heads. For vertical-down welding the test weld shall be made at the 12 o'clock pipe position and for vertical-up welding the test weld shall be made at the 3 o'clock pipe position. The length of the test weld shall be of sufficient length to accommodate all necessary destructive tests.

The qualification of remedial welding procedures shall simulate the production welding conditions and shall be subject to the same qualification and testing requirements as repair procedures.

Note: Remedial procedures are those that will be used to correct defects or flaws while the production joint is still above the minimum inter-pass temperature specified on the WPS.

11.7.8.2 External Repair Welding Procedure Qualification

Full penetration and partial penetration repairs only require procedure qualification testing when the pWPS contains changes that affect the essential variables of the original joint WPS (see Table 12). There may be scenarios where separate qualification is required at the discretion of the Gas Transporter.

Single stringer bead cap repair deposits are not permitted.

When required, full penetration repairs and partial penetration repair test welds shall be made between the 4 o'clock and 6 o'clock pipe position. Partial penetration repair test welds shall be centered on the weld cap fusion line and shall be equal or greater in depth than 50% of the pipe wall thickness (see Figure 8).

11.7.8.3 Internal Repair Welding Procedure Qualification

Note: Internal repair welding refers to repairs made from the inside of the pipe. This is also sometimes referred to as 'backwall' repair welding.

Single pass (root sealing) internal repair procedures are not permitted, except for those welds covered by the remedial welding procedure identified in clause 11.7.8.1 utilising mechanised systems with internal welding heads.

Multi-pass internal partial penetration repairs to double-sided joints only require procedure qualification testing when the agreed pWPS contains changes that affect the essential variables of the original joint WPS (see Table 12).

Multi-pass internal partial penetration repair test welds made on single-sided joints shall be prepared and welded in accordance with the agreed pWPS. The excavation shall be centered on the weld root between the 4 o'clock and 6 o'clock pipe position and shall be equal or greater in depth than 50% of the pipe wall thickness (see Figure 8c).

Where it is proposed to carry out a root repair at the inner 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 individual weld runs deposited one on top of the other (see Figure 8d).

When the internal repair is carried out in accordance with the original WPS parameters for deposition of the root run, the test weld shall be subject to macro and hardness testing only (see clause 11.7.3 and 11.7.5). The macro-section for hardness testing shall be extracted from the location with the lowest heat input.

11.7.8.4 Multiple Repairs

Multiple attempts to repair a weld are not permitted unless specifically approved by the Gas Transporter. This option shall only be considered in exceptional circumstances and will require full technical justification to be supplied by the manufacturer or contractor before further welding. Where a re-repair is permitted by the Gas Transporter, it is conditional on further repair welding procedure qualification tests (that simulate the additional number of heat cycles applied), being satisfactorily carried out. All supplementary testing records, including the new repair WPS and the technical justification for a multiple repair attempt shall be submitted for the approval of the Gas Transporter prior to any acceptance being given.

11.7.9 Examination and Testing of Remedial or Repair Procedure Test Welds

The extent of examination and testing of a remedial or repair procedure test weld shall be in accordance with Table 8 and as applicable, Figure 8 of this specification. NDT shall be carried out in accordance with GIS/NDT2.

Table 8. Examination and Destructive Testing of Remedial and Repair Procedure Qualification Test Butt Welds > 114.3 mm OD.

Type of Tests Required	Type of Repair Welding Procedure and Extent of Testing						
	Internal Remedial (a)	External Remedial (a)	Full Penetration Repair (b)	Partial Penetration Repair (b)	Two-pass Cap Repair (b)	Multi-Pass Back-Weld Repair (b)	Two-Pass Internal Repair (c)
Visual	100%	100%	100%	100%	100%	100%	100%
RT /UT	100%	100%	100%	100%	100%	100%	100%
MPI / PT	100%	100%	100%	100%	100%	100%	100%
T/V Tensile	—	1	1	1	—	1	—
Bend test	—	2	2 (d)	2 (d)	2 (e)	2 (f)	2 (f)
Impact(g)	2 sets	3 sets	2 sets	3 sets	—	3 sets	—
Macro	1	1	1	1	1	1	1
Hardness	1	1	1	1	1	1	1
All-Weld (h)	—	—	1	—	—	—	—
CTOD (i)	—	2 sets	2 sets	2 sets	—	2 sets	—

Notes:

a) Testing of a remedial procedure is only required where the pWPS contains changes that affect the essential variables of the original WPS (see Table 12).

b) Testing of a repair procedure is only required where the pWPS contains changes affecting the essential variables of the original WPS (see Table 12).

c) When an internal two-pass repair pWPS contains changes that affect the essential variables of the original WPS, testing shall include weld and fusion line impact tests.

d) Side bend, or root & face bends dependent on wall thickness.

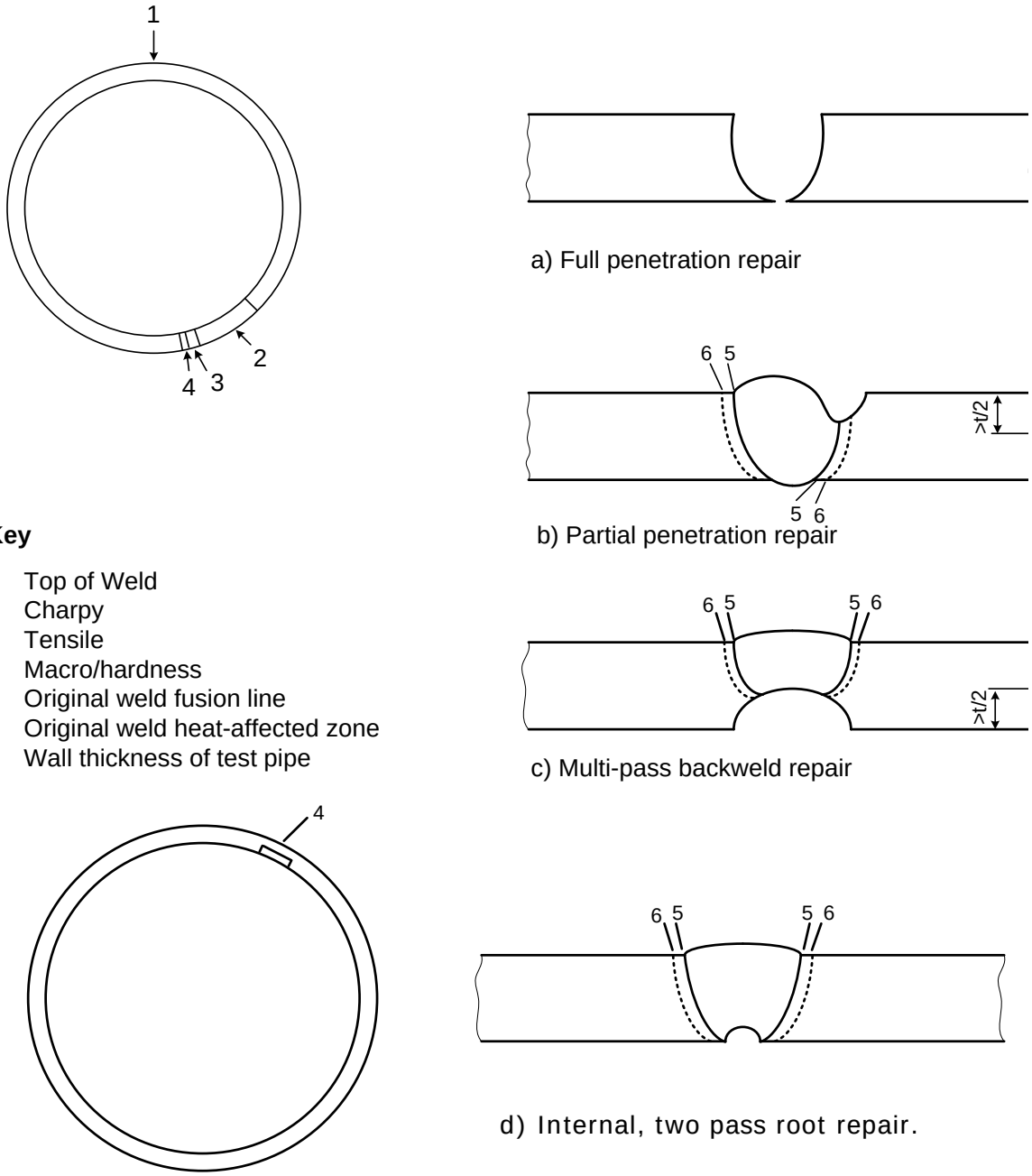
e) Face bends.

f) Root bends.

g) Additional sets of impact tests are required for each different heat affected zone.

h) When required by the Gas Transporter the specific requirements for all-weld tensile tests are given in 11.7.2.

i) When required by the Gas Transporter the specific requirements for CTOD tests are given in 11.7.6.3.



Key

1 Top of Weld
2 Charpy
3 Tensile
4 Macro/hardness
5 Original weld fusion line
6 Original weld heat-affected zone
t Wall thickness of test pipe

Figure 8. Location of Test Specimens for Butt Weld Repairs

Where a repair welding process or procedure is not identical to an approved mechanised or semi-mechanised welding procedure used to make the original joint, the number of specimens required to test the repair weld shall be as specified in Table 9. The Gas Transporter may require additional destructive tests (i.e., CTOD and/or all-weld tensile tests) from weld repair procedures joints. When CTOD testing is required by the Gas Transporter the requirements for testing shall be as specified in GIS/P2.

When required for procedure qualification, the Gas Transporter will specify the CTOD and AWT acceptance or re-testing criteria.

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

Type of Weld Repair	Type of Test and Number of Specimens				
	T/V Tensile	Bend Tests	Charpy Weld[d]	Charpy HAZ[d]	Macro/ HV [a]
Full-Penetration Repair	1	2 [b]	1 set	1 set	1
Partial-Pen. Repair	1	2 [b]	1 set	2 sets	1
Internal Root Repair	—	2 [c]	—	—	1

Notes:

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

b) Side bends or root & face bends dependent on wall thickness.

c) Root bends.

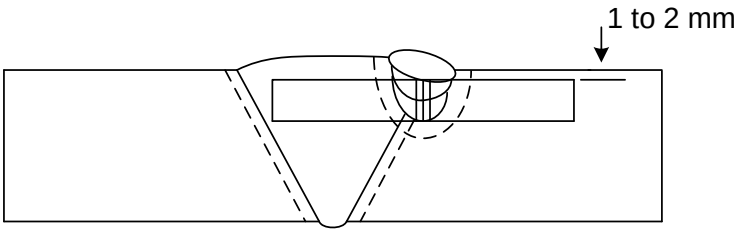
d) Additional sets are required when the thickness is > 20 mm, and the joint is made using dissimilar materials (e.g., pipe-to-fitting). See 11.7.4.2.

e) All-weld tensile testing and CTOD testing is only required when specified by the Gas Transporter.

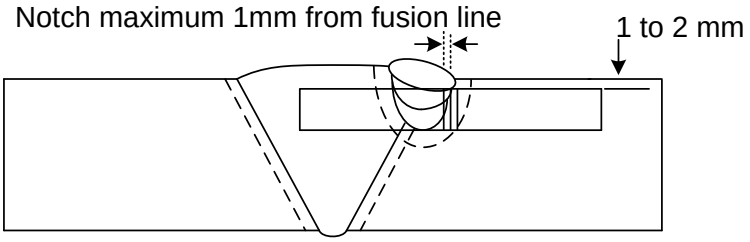
11.8 Destructive Testing of Procedure Repair Welds

The test methods for destructive testing of procedure repair welds are given in section 11.7.

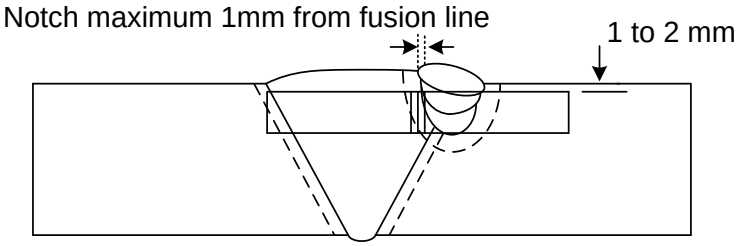
The notch locations for Charpy impact toughness testing of partial penetration repair welds are given in Figure 9.



Impact test notch location; Repair weld metal centre line



Impact test notch location; Weld HAZ 1



Impact test notch location; Weld HAZ 2

Figure 9. Location of Notch for Charpy Test Specimen from a Partial-Penetration Weld Repair.

11.9 Destructive Testing of Fillet Welds

The type, extent, and location of destructive test specimens shall be as shown in Table 5.

11.9.1 Fracture Test Specimens

Fracture tests shall be carried out in accordance with BS EN ISO 9017.

Fracture test specimens shall be taken from the locations shown to have the greatest and the least root gap. Accordingly, a record of root gap variation along the length of the test piece should be included in final WPQR package, and the appropriate locations clearly marked on the test piece to facilitate mechanical testing.

Test specimens shall be prepared as shown in Figure 10 and shall be at least 25 mm wide and at least 50 mm long.

Test specimens shall be prepared by machine or thermal cutting, followed by grinding to remove heat affected layer. The sides of the specimens shall be smooth and parallel.

11.9.2 Fracture Test

The specimen shall be broken using one of the following methods in such a way that the root of the weld is in tension:

a) supporting both ends and striking the centre of the specimen;

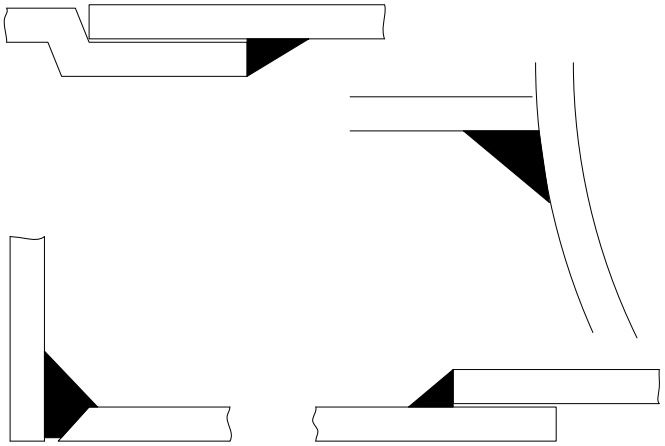
b) gripping one end of the specimen and striking the other.

11.9.2.1 Fracture Test Requirements

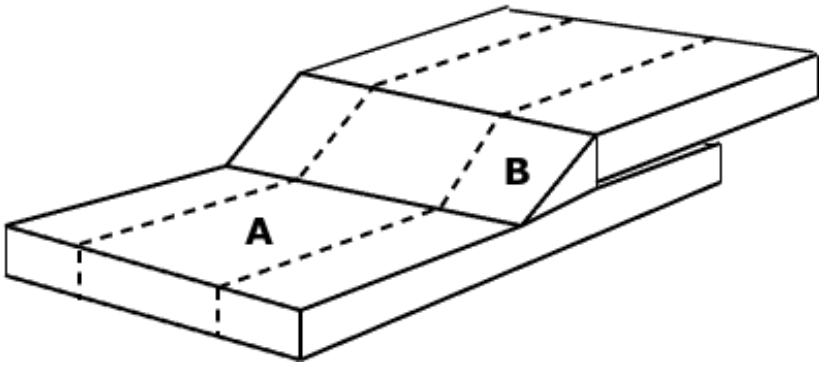
The exposed surface of each broken specimen shall be free of cracks, lack of fusion and lack of penetration. Inclusions and gas pore defects in the weld metal shall be within the following limits:

a) Inclusions shall not exceed 1 mm in depth and 3 mm or 50% of the pipe thickness in length, whichever is the shorter. There shall be at least 12 mm of sound weld metal between adjacent inclusions.

b) The greatest dimension of any gas pore shall not exceed 20% of the pipe thickness or 3 mm, whichever is the smaller. The combined area of all pores shall not exceed 5% of the exposed face cross-sectional area.

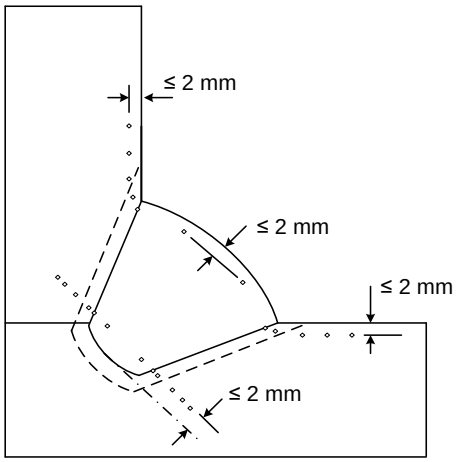


a) Typical Arrangement of Fillet Weld Test Specimens.



Notes:
1. The fracture specimens shall be at least 25 mm wide by 50 mm in length.
2. The off-cut sections may be used to prepare the macro specimens.
3. The macro specimens shall be used for the hardness surveys.

b) Preparation of Fillet Weld Fracture Test Specimen.



c) Locations of Hardness Survey for a fillet weld.

Figure 10. Preparation of Fillet Weld Test Specimens.

11.9.3 Macro-Examination

Macro test specimens shall be taken from the location shown in Figure 10. They shall be prepared, tested, and examined in accordance with clause 11.7.3.

11.9.3.1 Macro Test Requirements

The profile, dimensions, and number of runs of the fillet weld shall be as specified in the welding procedure. The specimen shall be free from cracks, lack of fusion and lack of penetration. The total area of any cavities or inclusions shall not exceed 5% of the fillet weld cross-sectional area.

11.9.4 Hardness Testing

Vickers hardness testing as per BS EN ISO 6507-1 with a 10 kg load shall be performed in accordance with BS EN ISO 9015-1 on all macro specimens. The hardness survey shall include two rows of indentations one made at a depth of up to 2 mm below the upper surface of the weld and one traverse across the root area of the weld made at a depth of up to 2 mm above the limit of root penetration. Hardness measurements shall be taken in both parent metals, the weld metal and in both heat affected zones to evaluate the range of hardness values across the welded joint (see Figure 10 c).

11.9.4.1 Hardness Test Requirements

The results of the hardness test shall meet the requirements of Table 7.

11.10 Destructive Testing – Permitted Weld Re-Tests

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 11.7.3 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.

11.11 Changes Affecting Qualification and Approval

In addition to the requirements of BS EN ISO 15614-1 and the essential variables listed in Table 12 of this specification, the conditions listed below shall apply:

a) 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.

b) The range of approval for the CE Value of materials tested by the welding procedure qualification test shall be within the tolerances specified in Table 13, or the welding procedure shall be re-qualified.

c) Consideration shall be given to the compatibility of equivalent materials that may be grouped in accordance with PD CEN ISO/TR 15608 (even though they fall within the CE Value range), to ensure that the design, post-weld heat treatment, metallurgical and mechanical properties will meet service requirements.

d) Even though a new material is considered equivalent to the procedure material tested and may be grouped in accordance with PD CEN ISO/TR 15608 and Table 14 of this specification, when required by the Gas Transporter, a weld (or welds) shall be produced using the approved welding procedure and tested in accordance with this specification to confirm that welds made in the new material meet the service requirements.

e) Procedure qualification of partial-penetration and full-penetration repair welds shall only be required when the proposed repair procedure is outside the range of qualification of the original welding procedure (see Table 12).

f) When impact requirements apply, the upper limit of heat input qualified is 10% greater than the range qualified in welding the test weld (see clause 11.5.2).

g) When hardness requirements apply, the lower limit of heat input qualified is 10% lower than the range qualified in welding the test weld (see clause 11.5.2).

h) When welding procedure tests have been carried out in accordance with the pWPS at both a high and a low heat input level, then all intermediate heat input values are also qualified.

i) When impact testing is not required, with the approval of the Gas Transporter, filler materials that have equivalent mechanical properties, the same type of covering, core or flux, nominal composition and the same or lower hydrogen content, according to the designation or classification in the appropriate standard for the original filler material concerned, may be substituted for the original filler material without the need for further testing. Where this is approved by the Gas Transporter the original WPS sheet shall be revised to show the permitted filler material demonstrating the equivalent classification.

11.11.1 Range of Approval for Set-On Fittings

The range of approval for set-on fitting diameter and carrier pipe diameter shall be as specified in Table 10 and Table 11.

The range of approval for carrier pipe wall thickness shall be as per Table 12, item (d).

The range of approval for the welding position of set-on branch connections is ± 25° of the position tested.

Table 10. 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 11. 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

11.12 Welding Procedure Qualification Record (WPQR)

A complete record of the welding procedure qualification test shall be produced by the manufacturer or contractor, this shall include all tests and re-tests undertaken during the qualification of the welding procedure. The WPQR (an example of which may be found in BS EN ISO 15614-1) shall detail all relevant items required to produce a WPS in accordance with BS EN ISO 15609-1. The WPQR shall be submitted along with the pWPS, the WPS and other necessary records for approval by The Gas Transporter.

Documentation to be included in a WPQR package is outlined in Section 17 Records.

Table 12. Welding Procedure Specification Details and Essential Variables.

Item		WPS Details	Essential Variable
Welding process	a1	The specific arc welding process (or combination of processes)	Any change
	a2	Manual, mechanised or semi- automatic	Any change
Parent material	b1	Specified strength grade	Any change other than that permitted by the ISO/TR 15608 grouping system and Table 13 and Table 14 of this specification
	b2	Heat treatment condition [(a)]	
	b3	Composition [(a)]	
Diameter	c	Nominal outside diameter, *D*, of pipe	Any change outside the range 0.5*D* to 2*D*
Thickness	d	Nominal wall thickness, *t*, of pipe	A change outside the range 0.75*t* to 2*t*
Joint configuration	e1	Type of bevel	Any change
	e2	Angle(s) of bevel [(b)]	Any change outside tolerances on approved WPS
	e3	Size of root face [(b)]	Any change outside tolerances on approved WPS
	e4	Width of root gap [(b)]	Any change outside tolerances on approved WPS
	e5	Use of backing rings	Any addition, deletion or change of material
	e6	Dimensions of fillet welds [(b)]	Not restricted as an essential variable
Electrode or filler material	f	The following information is needed for each weld run:	
	f1	Nominal diameter of electrode or filler core wire	Any change for the capping layer or the first two layers
			Any increase for other weld runs
	f2	Trade name	Any change when impact testing is required
	f3	Designation / Classification	Any change
	f4	Any pre-treatment or drying of hydrogen controlled electrodes	Any relaxation
	f5	Number of wires for each run	Any change
	f6	The addition of metal powders (process 121)	Any change
	f7	Welding with filler material or welding without filler material	Any change
Number of runs and number of sides welded	g1	Number of runs from each side	A change from single to multi-run or vice versa
	g2	Sequence of welding double sided joints	Any change to side welded first or last.

Shielding gas, backing gas[c] or flux	h1	Choice of shielding gas	Qualification is restricted to the groupings of the gas according to BS EN ISO 14175 *
	h2	Composition of any gas mixture for welding processes 131,135, 136 and 138	Restricted to the grouping of the gas according to BS EN ISO 14175. However, the content of CO_2 shall not exceed 10% of that used to qualify the procedure test
		Composition of any gas mixture for welding process 141	Restricted to the grouping of the gas according to BS EN ISO 14175
		* Shielding gases not covered by BS EN ISO 14175 are restricted to the nominal composition used in the test	
	h3	Gas flow rate [b, c]	Any change exceeding -10%
	h4	Trade name and flux type	Any change
Electrical characteristics	i	Current (A.C. or D.C.) and polarity	Any change
Welding parameters	j	The following information is required for each wire size (different values [b] may be used for different runs):	
	j1	**Electrical stick out [b]	Any change exceeding ±5 mm
	j2	**Wire feed speed [b]	Any change exceeding ±10%
		**(Processes 121, 131, 135, 136 & 138)	
	j3	Welding current [b]	Any change exceeding ±10% (±15% for cellulosic electrodes)
	j4	Arc voltage [b, d]	Any change exceeding ±10%
	j5	Calculated value of heat input (BS EN 1011-2) [b]	Any change ±10% of that tested
Welding Position	k	Angle of pipe axis to the horizontal	Any change exceeding ±25°
Direction of welding	l	Vertical up, vertical down, or horizontal	Any change
Welding technique	m	The following information is needed for each wire size used (different values [b] may be used for different runs)	
	m1	Maximum amplitude of any mechanised weave	To be agreed between the contracting parties
	m2	Frequency of any mechanised weave	To be agreed between the contracting parties
	m3	Dwell time at the side of any mechanised weave	To be agreed between the contracting parties
	m4	Number of welding torches used to deposit a single layer (e.g., single torch or twin torch systems)	Restricted to the torch system used in the procedure test
	m5	Wire system used in the procedure test (single wire or multiple wire system)	Restricted to the wire system used in the procedure test
	m6	Metal transfer mode for solid and metal cored wires	Dip transfer qualifies dip transfer only. Spray or globular transfer qualifies both spray and globular transfer

Number of welders	n	Number of welders for each pass	Any reduction
Time lapse between runs (cellulosic electrodes only)	o	Time lapse between the start of the root run and the start of the second run	Any increase
Partially completed joint	p	Number of runs before cooling to ambient temperature	Any reduction
Line-up clamp	q1	Internal, external, or alternative method detailed on the WPS sheet	A change from internal to external, or from clamp to alternative method
	q2	Number of runs before removal of the clamp	Any reduction
Pipe or fitting manipulators	r	Mechanical manipulators, jigs, or other mechanical means of supporting or moving the joint during welding	Any change from mechanical to manual methods of manipulation
Cleaning of bevel and weld	s1	Whether by power or hand driven tools [(a)]	No restriction
	s2	Whether weld back gouging is carried out using mechanical or thermal means	A change from mechanical to thermal means of metal removal
Preheating	t1	Preheat temperature	Any reduction, or an increase greater than 50°C
	t2	Method of applying heat	A change from an electrical heating method to a gas heating method
	t3	Method of controlling temperature	Any change
	t4	Method of measuring temperature	Any change
	t5	The initial temperature of pipe not requiring preheat	Any reduction
	t6	Maximum or minimum interpass temperature for each weld run	The upper limit is the maximum temperature attained during the test. The lower limit is the minimum preheat temperature used during the test (see Table 21)
Post-weld heat treatment (a)	u1	The addition or deletion of post weld heat treatment	Any change
	u2	Method of applying heat	Any change
	u3	Soaking/holding temperature	Any change ± 10 °C
	u4	Soaking/holding time	Any change + 30 minutes, - 0 minutes
Post heating for hydrogen release (a)	u8	The addition or deletion of post heating	Post heating may be added but not omitted
	u9	Temperature and duration of post heating for hydrogen release	Any reduction
Repair welds	v1	Welding procedure details for repair welding	Any of the changes affecting approval listed above

	v2	Welding procedure details for the weld to be repaired	Any change affecting the approval of the procedure for the weld on which the repair welding procedure was qualified

Notes:

a) These items shall be specified on the preliminary WPS sheet but are not mandatory for the production WPS sheet if they are controlled through other procedures.

b) These parameters shall be specified as single nominal values on the preliminary WPS sheet but as qualified ranges (nominal values ± permitted variation) on the production WPS sheet. In cases where the mean value measured in qualification differs from the nominal value, the qualified range shall be calculated from the mean value measured in qualification.

c) A welding procedure test made without backing gas qualifies a welding procedure with backing gas, but not vice versa.

d) The length of welding leads/cables will affect the arc voltage. This should be taken into account during WPQT.

Table 13. Carbon Equivalent (CE) Value– Range of Qualification.

CE Value Tested	Limit of Qualification
≤ 0.43%	+ 0.05 % of that tested up to a maximum CE Value of 0.45%.
> 0.43%	Not greater than 0.02% above that tested.
$CE\ Value\ (IIW)\ (\%) = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$	

Table 14. Range of Qualification for Steel Groups and Sub-Groups (Extracted from BS EN ISO 15614-1, Table 5.)

Material Group Welded & Tested[a]	Range of Material Groups Qualified [b]					
	1.1	**1.2**	**1.3**	**2.1**	**2.2**	**3.1**
1.1	●	—	—	—	—	—
1.2	●	●	—	—	—	—
1.3	●	●	●	—	—	—
2.1	●	●	●	●	—	—
2.2	●	●	●	●	●	—
3.1	●	●	●	●	●	●

Notes:

a) Covers the equal or lower specified yield strength steels of the same group.

b) The range of qualification may not apply to test welds or production welds which involve post weld heat treatment.

12 WELDERS – TESTING, QUALIFICATION AND APPROVAL

12.1 General

Testing for the approval of manual welders shall be in accordance with BS EN ISO 9606-1. A welder who has successfully welded a procedure approval test is automatically qualified to weld using that procedure.

Alternatively, at the discretion of the Gas Transporter, a welder may be qualified on the first production weld, not to include fittings. This shall include not less than 100% of one side of a complete weld joint from 12 o'clock through to 6 o'clock position, or the equivalent specified welding positions.

Full penetration set-on branch attachment welds shall be classed as butt welds.

In order to reduce the number of welder approval tests, the use of a welder approval from a particular weld procedure may be applied to other joint types, providing the essential variables and other limitation of BS EN ISO 9606-1 and this specification are met.

Subject to the agreement of the Gas Transporter, the use of specific welder approval tests utilising variables that allow the application of the approval to a range of joints (type, size, and configuration etc.) is permitted.

The essential variables for the qualification of manual welders are as follows:

a) Welding process, or combination of processes

b) Plate or pipe test

c) Joint type

d) Filler material group

e) Filler material type and covering

f) Pipe thickness and diameter as defined in Table 15 and Table 16

g) Welding positions as defined in Table 17 and Table 18

h) Details of test weld including backing, single sided welding, welding from both sides, single layer, multi-layer etc.

12.2 Essential Variables Affecting Approval

12.2.1 Welding Process

Any change in the welding process or combination of processes from that/those used during approval shall be reapproved. Exceptions may be where the approval test was carried out using a solid wire (process 135) and will also approve welding using a metal cored wire (process 138) and vice versa.

12.2.2 Plate or Pipe Test

Welds in pipe will cover welds in plates providing the approval test was carried out on pipe of 33.4 mm or greater.

Welder approval tests carried out in plate shall approve the welder to weld pipes of 168.3 mm and greater in positions PA rotated, PB rotated, and PC rotated only.

12.2.3 Joint Type

Approval test carried out on butt welds shall qualify all joint types providing other essential variables are satisfied, except for branch connections where a separate test is required.

Where the work predominately involves fillet welds, approval shall be carried out on a fillet weld test. Similarly, where the majority of work involved butt welds, the approval shall be carried out on a butt weld approval test.

Branch connections with an angle of 60° and greater may be covered by an approval test in pipe providing the weld was carried out without backing and all other requirements of BS EN ISO 9606-1 are met.

As noted in clause 11.5, types of weld that cannot be qualified by means of a butt or fillet weld shall be qualified separately and cannot be used for multiple approvals.

12.2.4 Filler Material Group

Approval test shall use a consumable (filler material) specified in Table 2 of BS EN ISO 9606-1, using filler material groups FM1 and/or FM2.

The range of approval of a welder performance test using an FM2 filler material shall allow a welder to weld to a qualified procedure using FM1 filler metal, and vice versa.

For process 141, welding with filler metal shall approve welding without filler metal, but not vice versa.

12.2.5 Filler Material Types & Covering

For welding process 111, the range of approval for covered electrodes are shown in Table 4 of BS EN ISO 9606-1.

The range of approval for filler material type are shown in Table 5 of BS EN ISO 9606-1.

12.2.6 Thickness – Range of Qualification

The range of approval for thickness of pipes and fittings is given in Table 15.

Table 15. Range of Qualification for Thickness of Pipes and Fittings.

Type of Weld	Nominal Thickness of Test Piece, *t*	Range of Qualification
Butt	< 12 mm	3 mm – 2*t*
	≥ 12 mm	≥ 3 mm
Fillet	≥ 3 mm	≥ 3 mm

a) Data summarised from Table 6 and Table 8 of BS EN ISO 9606-1.

b) For pipeline and pipework butt welds the deposited thickness (*s*) is usually the same as the nominal thickness of the test piece (*t*).

c) Thicknesses less than 3.2 mm are not covered by this specification.

d) For branch connection, the thickness is determined by the following:

- Set-on (full penetration butt welds) – thickness of the branch
- Set-on (partial penetration butt welds) – thickness of the branch
- Set-through – material thickness of the main (header) pipe

12.2.7 Diameter – Range of Qualification

The range of approval for pipe and fitting diameters is given in Table 16.

Table 16. Range of Qualification for Diameter of Pipes and Fittings.

Outside Diameter of Test Piece, *D*	Range of Qualification
D ≤ 33.4 mm	*D* – 2*D*
D > 33.4 mm	≥ 0.5*D* (33.4 mm min.)

Note: For both set-on and set-through branch connection, the diameter is determined by the outside pipe diameter of the branch.

12.2.8 Dissimilar Thickness and Diameter

When the approval test involves test pieces of different pipe diameters and thicknesses the welder carrying out the test will be approved for the approved ranges for both thickness and diameter based upon the thinnest and thickest materials and also the smallest and largest diameters of pipe.

12.2.9 Welding Positions

The range of welder approval for weld positions are summarized in Table 17 and Table 18. Majority of the pipe production welds are performed at PH (5G uphill) and PJ (5G downhill). PH and PJ welding positions can only be qualified by welding a welder approval test in PH & PJ respectively.

Test pieces shall have no deviation from the vertical or horizontal direction greater than 25º.

Certain clauses as per BS EN ISO 9606-1 are as follows:

a) Welding positions J-L045 (6G vertical-down) and H-L045 (6G vertical-up) for pipes approves the welding of pipes in all orientations for the respective welding directions.

b) Carrying out an approval test on two pipes of the same outside diameter, one in the PC (2G horizontal-vertical) position and one in the PH (5G vertical-up) position covers the range of approval of a pipe welded in the H-L045 position.

c) Carrying out an approval test on two pipes of the same outside diameter, one in the PC (2G horizontal-vertical) position and one in the PJ (5G vertical-down) position covers the range of approval of a pipe welded in position J-L045.

d) One approval test piece in the form of a pipe welded 2/3 in the PJ or PH position and the remaining 1/3 of the circumference in the PC position will approve the welding of pipes of outside diameters *D* ≥ 168.3 mm for all positions in the directions of welding used in the test.

Table 17. Range of Qualification for Welding Positions – Pipe Butt Welds.

Position of Test Piece	Range of Qualification					
	PA	**PC**	**PH**	**PJ**	**H-L045**	**J-L045**
PC	Yes	Yes	—	—	—	—
PH	Yes	—	Yes	—	—	—
PJ	Yes	—	—	Yes	—	—
H-L045	Yes	Yes	Yes	—	Yes	—
J-L045	Yes	Yes	—	Yes	—	Yes
a) Summarised from Table 9 in BS EN ISO 9606-1. b) Welding positions are defined in BS EN ISO 6947.						

Table 18. Range of Qualification for Welding Positions – Fillet Welds.

Position of Test Piece	Range of Qualification					
	PA	**PB**	**PF**	**PG**	**PH**	**PJ**
PA	Yes	—	—	—	—	—
PB	Yes	Yes	—	—	—	—
PF	Yes	Yes	Yes	—	—	—
PG	—	—	—	Yes	—	—
PH	Yes	Yes	Yes	—	Yes	—
PJ	Yes	Yes	—	Yes	—	Yes
a) Summarised from Table 10 in BS EN ISO 9606-1. b) Welding positions are defined in BS EN ISO 6947.						

12.2.10 Details of Test Weld

Butt Welds

Approval test welding single sided without backing shall approve a welder to also weld single sided with backing and from both sides.

Approval test welding single sided with backing shall approve a welder to also weld from both sides. Approval test welding from both sides shall approve a welder to also weld from one side with backing.

Other test details for butt welds shall have limits of approval as per BS EN ISO 9606-1.

Fillet Welds

A single pass fillet weld approval test does not approve a welder for multi pass fillet welding. A multi pass fillet weld approval test will approve a welder for single pass fillet welding.

12.3 Visual Examination

The test weld shall present a neat workmanlike appearance and shall be assessed by visual examination to BS EN ISO 17637 according to the appropriate acceptance criteria specified in clause 14.2 of this specification. The results of the examination shall be recorded.

12.4 Non-Destructive Testing

Non-destructive testing shall be carried out on each of the test welds by X-radiography as specified in clause 14.3.

Manual phased array UT may be used in lieu of X-radiography. When manual phased array UT is used, bend testing shall be carried out as well.

The NDT of the test welds shall be assessed in accordance with clause 15.1.

12.5 Destructive Testing

12.5.1 General

Destructive testing shall be used for examining butt welds where it is not feasible to carry out non-destructive testing. Destructive testing may be required to confirm interpretation of the results of non-destructive testing.

Fillet welds shall always be subjected to destructive testing.

12.5.2 Butt Welds

The testing of butt welds for welder approval shall comply with the requirements as outlined in BS EN ISO 9606-1. Test piece dimensions and geometries shall be in accordance with BS EN ISO 9606-1 for plates and pipes.

Bend Testing

Bend tests shall be carried out in accordance with BS EN ISO 5173. Former and inner roll details are defined in BS EN ISO 9606-1 section 6.5.2.3.

For pipes of outside diameter of 33.4 mm and less, bend tests may be replaced by a notched tensile test of the entire approval test piece as defined in Figure 9 of BS EN ISO 9606-1.

For thicknesses of 12 mm and greater, transverse bend test samples may be replaced by side bend tests.

For welding processes 131, 135, 136 and 138, additional bend or fracture tests shall be carried out to complement the non-destructive testing.

Fracture Testing

Fracture tests shall be carried out in accordance with BS EN ISO 9017.

For pipes of 33.4 mm and less, fracture tests may be replaced by a notched tensile test of the entire approval test piece as defined Figure 9 of BS EN ISO 9606-1.

The examination length of each test specimen shall be at least 40 mm, or greater.

12.5.3 Fillet Welds

The testing of fillet welds for welder approval shall comply with the requirements as outlined in BS EN ISO 9606-1. Test piece dimensions and geometries shall be in accordance with BS EN ISO 9606-1.

Fillet weld approval testing shall be in accordance with the visual method as described above and either fracture testing, macroscopic examination or when the approval has been carried out on pipe, radiographic testing.

Fracture Testing

Fracture tests shall be carried out in accordance with BS EN ISO 9017.

For fracture testing of pipe, the test piece shall be cut into at least four (or more if possible) separate specimens and each specimen shall be individually fractured.

Macroscopic examination may be used to replace the use of fracture tests with the testing of at least two sections in accordance with BS EN ISO 17639, or section 11.7.3 of this specification, with the omission of the hardness testing. One macroscopic specimen shall be taken from a stop start area.

12.5.4 Acceptance Criteria for Tests

The results of tests outlined in clause 12.5 shall satisfy the acceptance criteria in clause 15.1 and the following:

- The welder approval test need not be assessed for angular misalignment.
- Bend test specimens shall not reveal any discrete discontinuity ≥ 3 mm in any direction. Discontinuities appearing at the edges of the bend test specimens shall be ignored in the evaluation and will not be classed as a failure unless the resultant cracking is attributable to incomplete penetration, slag, or another type of flaw.

12.6 Retests

In the event of a test failing to meet the requirements of BS EN ISO 9606-1, the welder may be allowed the opportunity to repeat the approval test.

When the contracting parties agree that the failure was due to conditions beyond the welder's control, then an additional test is required to verify the quality and integrity of the new test material and /or new test conditions.

12.7 Records

The details of each welder's approval test and test results shall be recorded. All documentation relating to welder approval tests shall be submitted to the Gas Transporter for approval prior to the welder commencing production work.

Record forms similar to the example shown in Annex A of BS EN ISO 9606-1 should be used. The period for which records should be kept should be specified by the Gas Transporter.

12.8 Period of Validity

The welder's qualification shall remain valid for two years from the date of successful testing of the test piece. Every six months the welder's production performance shall be reviewed to confirm that the welder has been satisfactorily working within the initial range of qualification.

Note: This is system (b) in Section 9.3 of BS EN ISO 9606-1.

Providing that evidence (see BS EN ISO 9606-1) is available to confirm this, the welder's qualification remains valid. If the required evidence is not available to confirm validity the welder shall be re-tested.

12.9 Mechanised Welding

For mechanised welding, each welder shall be approved for all parts of the operation of making a weld. A change in the type of welding equipment or system shall require re-approval of the welder.

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 provision of BS EN ISO 14732.

13 PRODUCTION WELDING

13.1 General

Adequate provision shall be made for the removal of welding fumes and dust at the workplace, the provision of PPE shall be considered a secondary level of employee protection.

All welding, including tack welding shall be performed by qualified welders in accordance with the approved WPS.

All fittings shall be welded in accordance with the approved WPS and the weld completed in a single heat cycle. The root run shall be deposited in the vertical up direction (PH) for pipe joints made in the fixed horizontal position, using process 111 (MMA).

All fillet welds shall be welded using a low hydrogen process.

Copies of the approved welding procedures shall be available at the work location. Welders and Welding Inspectors shall be fully familiar with the approved welding procedures.

13.2 Proximity of Welds

All welds should be separated by the maximum possible distance. However, the following shall apply:

a) Adjacent circumferential welds shall be separated by:

    a. 250 mm minimum for pipe diameter ≥ 323.9 mm.

    b. One pipe diameter minimum for pipe diameter < 323.9 mm.

b) Full penetration forged set-in branch welds adjacent to circumferential or longitudinal welds shall normally be not less than 100 mm apart.

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.

The Gas Transporter shall be informed of any deviation to this requirement and will decide whether the joint may be welded, or whether further modification to the pipework is required to ensure compliance.

In-situ welding of fittings (equal to or greater than 457 mm outside diameter) during the assembly of installation pipe work should have pipe-pups welded to them under fabrication shop conditions before being welded in the field. The pup length shall be not less than 250 mm.

When space restrictions prohibit bends, tees or valves fitted with pipe-pups being installed or results in a fitting being welded to a fitting, special care shall be taken with the joint set-up and the application of pre-heat.

The production route shall be planned to ensure that, where necessary, back grinding of root beads and inspection of the root weld is maintained. This is particularly important for fittings e.g., set-in sweep-o-let type. To facilitate welding, repair and inspection, the use of pipe-pups interposed between fittings and branches is preferred.

13.3 Pipe and Fitting End Preparation

Pipe and fitting ends shall be bevelled by machining or machine thermal cutting (which may be manually or mechanically operated). Manual thermal cutting shall not be used. Alternatively, with the approval of the Gas Transporter, the bevel may be produced by grinding to the dimensions specified in the WPS.

When thermal cutting is used on pipes or fittings to prepare them for welding, the heat affected zone shall be removed by grinding or machining. Typically, the heat affected zone is taken to be 3 mm wide, although this should be considered on a case-by-case basis.

When welds are cut-out and the pipe or fitting is to be reclaimed for re-welding, the heat affected zone(s) from the weld shall be removed by grinding or machining. Typically, the heat affected zone is taken to be 3 mm wide, although this should be considered on a case-by-case basis.

With the approval of the Gas Transporter, minor imperfections such as burrs, small score marks, indentations or similar flaws on the bevel face shall be removed by grinding or the joint shall be fully re-prepared. Correction by grinding may be approved providing that the specified bevel dimensions are maintained within the specified tolerances. Note however that most bevel configurations designed for welding by automatic or fully mechanised processes are produced by machining and subsequently may be intolerant of bevel flaws or damage.

Damage to the surface of the pipe or fitting by bevelling machines shall be repaired by dressing. After dressing the remaining wall thickness shall be measured to confirm that the thickness of the pipe or fitting remains within the permitted tolerances of the material specification.

The manufacturer or contractor shall ensure that the bevelled surface and the adjacent pipe or fitting surface are free of scale, rust, paint, grease, fins, tears, moisture, or other foreign matter immediately prior to welding. Cleaning to base metal shall extend a minimum of 25 mm from the edge of each fusion face on both the external and internal surfaces of the joint.

Pre-fabrication weldable primers may be applied and left on fusion faces provided that it has been demonstrated during welding procedure qualification that they do not adversely affect the quality of welding or produce unacceptable fumes.

The non-destructive requirements for ultrasonic testing of cut pipe ends and pipe areas for welded attachments is specified in GIS/NDT2.

13.4 Fusion Faces

The manufacturer or contractor shall ensure that material adjacent to weld preparations in pipe is free from laminations or other planar flaws greater than 25 mm in any direction. Laminations or other planar defects found in pipe fusion faces are not permitted (see GIS/NDT2).

Fusion faces not complying with these requirements shall be re-prepared before welding. All coatings other than fusion-bonded epoxy (FBE) shall be cut back not less than 150 mm.

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 shall be removed. Scraping, blast cleaning or a suitable stripping agent is an acceptable removal method. It is recommended that removal by heating is not used.

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

13.5 Alignment

For pipes of different nominal wall thickness, alignment shall be achieved in accordance with GIS/P16.

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

Correct joint alignment shall be achieved prior to welding and shall ensure that:

- 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 19, excessive misalignment shall be corrected in accordance with the approved method statement before welding.

- Production routes shall be planned by the manufacturer or contractor to ensure that longitudinal (SAWL and HFW) and / or spiral (SAWH) welded seams of adjacent pipes shall be offset by not less than 100 mm at the girth weld.

- No force other than that exerted by approved line up clamps shall be used to spring or superimpose additional stresses on any component for alignment purposes during construction.

- 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.

- For socket joints, the pipe end shall be inserted fully into the socket and then withdrawn 2.0 mm +0.5/-0 mm (see Figure 11). This gap is vital to the integrity of the finished joint. The assembly shall be checked to be squarely aligned and any necessary adjustment made prior to tack welding (see clause 13.5 and 13.7).

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, or borescope camera to confirm the original joint fit-up.

Table 19. Weld Joint Alignment Tolerances.

Wall Thickness, *t* (mm)	**Permitted Misalignment of Abutting Surfaces**	
	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.
* Unless a smaller tolerance is specified by the pipe work designer.		

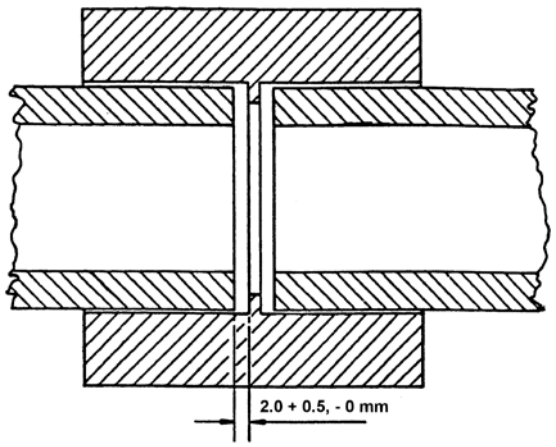


Figure 11. Socket Weld Configuration Prior to Welding.

13.6 Alignment Clamps and Pipe Supports

Line up clamps shall be used where practicable to align and hold components prior to and during welding. Any other method of alignment shall be approved by the Gas Transporter prior to use (see Table 2). Under no circumstances shall brackets, cleats or other temporary attachments be welded to the components for alignment purposes.

Internal line up clamps shall not be released before completion of the root run or at a later stage specified on the qualified WPS. External line up clamps shall not be released until at least 50% of the root run, equally spaced around the joint, has been completed. The joint shall remain fully supported either side of the weld during welding.

When external line-up clamps are used, precautions shall be taken to minimize coating damage. Such clamps, and also earth returns, shall not be dragged along the pipe but lifted into place. When using mechanised welding machines, the support frames shall be adequately padded and the buttons, on externally fitted bands, shall be profiled to eliminate coating damage.

13.7 Tack Welds

When required, the components forming the joint shall be tack welded to maintain alignment during welding. Only qualified welders working to an approved procedure will be permitted to carry out tack welding. The minimum number and size of tack welds deposited shall be as specified in Table 20. There may be instances when more tack welds are required to secure a joint. Each situation shall be assessed by suitably qualified and experienced personnel.

Tack welding is only permitted within the joint profile.

Welds onto the external or internal surfaces for fit-up and alignment purposes are not permitted without Gas Transporter prior approval.

Root tack welds shall only be used when a non-slag forming process, such as TIG, is used for the root pass. They shall be made in accordance with that part of the approved welding procedure that is used for the root run, and shall only be used when they are part of the same heat cycle as used for the root pass. Pre-heating shall be in accordance with the approved WPS. The root tack welds shall be of suitable shape and profile to be incorporated in the root run and shall be free of cracks or other unacceptable defects.

‘Bullet’ tack welds shall be used for MMA welds. The ‘bullets’ shall be of a metallurgically compatible material, and fusion shall be on the bevel face – not the root face. Bullet tack welds shall be made using agreed parameters. Each bullet tack shall be removed (by grinding) as the root pass progresses.

Tack welds which include unacceptable defects, or have cracked, shall be completely removed prior to welding.

When the joint is to be welded using a fully mechanised or automatic welding process, the type and extent of tack welds (if required) shall be specified in the WPS.

Table 20. Tack Welding Requirements.

Outside Diameter	Minimum Number of Tack Welds	Minimum Length of Each Individual Tack Weld
Socket joints ≤ 48.3 mm	2	12 mm
≤ 114.3 mm	3	25 mm
168.3 – 406.4 mm	4	25 mm
≥ 406.4 mm	4	50 mm

Notes:

a) There may be instances when more tack welds are required to secure a joint. Each situation shall be assessed by suitably qualified and experienced personnel.

b) Tack welds shall be equally distributed around the joint.

c) Root tack welds, when used, shall be of suitable shape and profile to be incorporated in the root run.

Bridge tack welding may only be carried out when approved by the Gas Transporter. The manufacturer or contractor shall submit a bridge tack welding procedure for approval by the Gas Transporter.

Note: A bridge tack is made using weld metal to connect the two sides of a joint. Unlike a bullet tack, no additional material is added.

When socket joints have reached the minimum pre-heat temperature, the assembly may be tack welded in accordance with Table 20 in order to maintain alignment during the welding cycle. 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.

The workpiece shall not be left in the tacked condition for a prolonged period of time.

A written procedure shall be produced by the contractor/subcontractor for tack welding.

13.8 Welding Earth Connections

Welding return cables shall be of sufficient cross-sectional area to prevent current concentrations and shall be securely attached to the work-piece to prevent arc burns. Any accidental arc burn caused by a faulty connection shall be removed in accordance with the requirements of clause 13.12.

13.9 Working Clearance

Sufficient access shall be provided adjacent to and around the weld for all activities associated with preparation, welding, and NDT inspection of the welded joint.

During the assembly of pipe work and fabrications it may be necessary to work in a trench. In such cases, the bell hole or excavation shall meet the current statutory and Gas Transporter requirements. Details of a typical bell hole excavation are shown in Appendix E.

Standing water shall be removed prior to welding commencing.

13.10 Background Lighting

Attention is drawn to the need for adequate workplace lighting, both in a workshop and on site, to provide safe working conditions and to meet specified minimum illumination levels for the inspection of welds.

Background lighting should be in accordance with T/PM/EL/1 Table 1 for interior illumination levels and T/PM/EL/1 Table 2 for exterior illumination levels for working areas. GIS/NDT2 specifies the required viewing conditions and lighting levels for visual and magnetic particle inspection.

13.11 Weather Conditions

Welding shall not be undertaken when, in the opinion of the Gas Transporter and following consultation with the manufacturer or contractor the quality of the completed weld may be impaired by airborne moisture, blowing debris or high winds. The method of providing weather protection proposed by the manufacturer or contractor shall be approved by the Gas Transporter

Weather 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.

13.12 Stray Arcs

Arcs shall be struck only on the fusion faces of the joint. In order to reduce the risk of unintentional arc strikes, electrode holders shall be of the fully insulated type.

Material affected by an arc strike shall, with the agreement of the Gas Transporter, either be repaired or rejected. Not more than one arc strike per weld may be repaired and two or more arc strikes will be cause for the complete removal of the weld and damaged pipe material.

Where the Gas Transporter agrees that an arc strike may be repaired, it shall be removed in accordance with a documented procedure that defines the methods for mechanical removal of the defective material, blending of the excavation, magnetic particle inspection and ultrasonic wall thickness measurement of the dressed area to confirm that the pipe or fitting is within permitted tolerances.

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

The application of a weld deposition repair is limited to pipe material grade ≤ L450 (or X65) and shall not be applied to pipe work that will be subject to pressure cycling that could affect the designed fatigue life of the component.

13.13 Preheating

13.13.1 General

Preheating shall be applied uniformly to the components to be welded by gas flame or electrical methods. The minimum preheat temperature to be applied and the method of heating shall be in accordance with the approved welding procedure. A zone of at least 75 mm from each side of the weld (extending completely around the circumference of the joint for pipe work welds) shall be maintained at the specified temperature.

Electrical heating methods include resistance heating pads and induction heating coils. The method of electrical heating proposed by the manufacturer or contractor shall be approved by the Gas Transporter.

Oxy-propane heating shall only be used with the agreement of the Gas Transporter. And when permitted, it shall have been used in the qualification of the welding procedure. Measures shall be taken by the manufacturer or contractor to prevent component materials being overheated and where applicable to prevent unnecessary damage to the component coating.

The minimum preheating and maximum weld inter-pass temperatures shall be as specified in Table 21 (unless a higher pre-heat temperature is required based on the results of material weldability trials or if specified in the manufacturer or contractor’s proposed welding procedure).

Note: Further guidance on preheating is given in BS EN ISO 13916.

13.13.2 Preheating

The joint shall be preheated to the minimum temperature specified in the WPS and shall not exceed this temperature by more than 50°C.

The minimum pre-heating temperature shall be confirmed using temperature-indicating crayons (which melt when the required temperature is reached), contact thermometer, or by thermocouples attached to the work piece. In the latter case the method of thermocouple attachment and removal shall be approved by the Gas Transporter.

Crayons or paints that indicate temperature by colour change; or infra-red pyrometers are not permitted. The component temperature shall be measured immediately prior to welding and around the entire periphery of the joint while welding is taking place.

13.13.3 Weld Inter-Pass Temperature

The weld inter-pass temperature is defined as the temperature of the work-piece adjacent to the weld immediately prior to commencement of the next weld pass.

The weld inter-pass temperature shall not fall below the minimum pre-heat temperature specified in the approved welding procedure specification.

The maximum weld inter-pass temperature shall not exceed that qualified during procedure testing.

13.13.4 Air-Arc Gouging

Where 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 commencing (see Table 21).

Table 21. Preheating Temperature Requirements.

Component Configuration	Material Grade	Wall Thickness	Minimum Preheating Temperature	Minimum Weld Inter-pass Temperature
Pipe-to-Pipe	L245 (Gr B) L290 (X42) L360 (X52) L415 (X60)	< 19.1 mm	50°C	50°C
		≥ 19.1 mm	100°C (a, b)	100°C (c)
	L450 (X65) L485 (X70)	< 19.1 mm	50°C	50°C
		≥ 19.1 mm	100°C (a, b)	100°C (c)
	L555 (X80)	All	100°C	100°C
Pipe-to-Fitting Fitting-to-Fitting	All	All	150°C (b)	150°C (b)
Set-on Fittings	All	All	150°C (b, d)	150°C (b, d)
Isolation Joints	All	All	50°C (e)	50°C (e)
Ball Valves (unpupped)	All	All	50°C (e)	50°C (e)
Socket joint	All	All	75°C (f)	75°C (f, g)
CP Plates	All	All	75°C (f)	75°C (f)
Air–arc gouging (Repair excavation)	All	All	As per applicable WPS.	—

Notes:

a) The temperatures stated assume a maximum component nominal wall thickness at the weld bevel face of 28.3 mm. The need for any higher preheat temperature to be applied for component thicknesses greater than this shall be determined by satisfactory welding procedure qualification.

b) When welding in workshop conditions and agreed with client welding engineer, lower preheat and interpass temperatures may be qualified for low hydrogen welding processes.
Suitable minimum preheat temperatures can be calculated in line with BS EN 1011-2 using the maximum qualified range to calculate combined thickness.

c) Lower interpass temperature of 80°C may be applied when the fill and cap passes are deposited with low hydrogen welding processes.

d) Care shall be taken not to overheat set-on fittings.

e) Higher material grades and thicker components may necessitate the use of low hydrogen welding processes.

f) Socket joint and CP plate assemblies shall not be heated above 150°C. Care shall be exercised to prevent overheating of the pipe and fitting.

g) 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.

13.14 Post Weld Heat Treatment

13.14.1 General

The PWHT of welds is only required when specified by the design standard or code. The requirement for the PWHT shall be identified in the approved WPS and shall be defined in a PWHT specification submitted by the manufacturer or contractor for the Gas Transporters approval.

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

13.14.2 Post Weld Heat Treatment Temperatures

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

13.15 Branches

All branch connections shall be at right angles to the axis of the pipe, they shall be made using specialised fittings (e.g., forged or pressed tees, or forged set-in or set-on components) in accordance with the requirements of GIS/PW/11: Part 1.

Where pipes are to be lagged, branch connections shall have not less than 100 mm of plain pipe before any flanged fittings, to ensure that the fittings are clear of the lagging.

13.15.1 Spacing of Branches

Forged set-in branches adjacent to circumferential or longitudinal welds shall not be less than 100 mm apart unless special circumstances require closer proximity in which case special consideration shall be given to each application and will require approval by the Gas Transporter (see clause 13.2).

The spacing of branches on the main pipe and the length of flanged branches shall allow access for welding and subsequent NDT.

13.15.2 Branch Joint Preparation

Prior to cutting out a branch opening in a main pipe, ultrasonic examination of the area of branch attachment shall be carried out in accordance with the requirements of GIS/NDT2.

Branch connections and branch openings in the main pipe shall be cut by machine or by thermal cutting methods. The edges of the pipe shall then be prepared by filing or grinding to the dimensions specified in the approved WPS (see also clauses 13.2 and 13.3).

13.15.3 Branch Joint Welding

Branch fittings shall be fully supported during alignment and welding. Special jigs or clamps may be required to support set-in type fittings (see clause 13.5).

A constant root gap shall be maintained during deposition of the root run. Tack welding shall be in accordance with clause 13.7. The use of an internal weld bead shall only be permitted when specified in the approved WPS.

13.16 Socket Welds

The 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 (see Table 21).

For horizontal socket joints, unless otherwise agreed by the Gas Transporter, welding shall be in the vertical-up direction (PH). Socket fillet weld leg lengths shall be equal. The weld profile shall not be concave, and unless otherwise specified, the fillet weld leg length shall be 1.4 times the pipe wall thickness. Care shall be taken to prevent the top edge of the socket fitting being removed or melted.

13.17 Inter-Run Cleaning

Each run of weld metal shall be thoroughly cleaned using hand or power tools before a further weld run is applied.

The weld shall be visually checked between runs by the welder to ensure that slag and other visible flaws or deposition faults have been identified and removed before welding continues.

Particular attention shall be paid to the cleanliness of the junction between the weld metal and the fusion faces. Clusters of surface porosity, individual pores and/or high points shall be removed by grinding. Where necessary, stops and starts may be ground smooth to ensure fusion of the subsequent weld run pick up.

The cause of any visible cracks or crack-like indications found during welding shall immediately be investigated by the manufacturer or contractor and reported to the Gas Transporter or to the Gas Transporters representative.

Should a crack be confirmed then the complete joint shall be cut-out and removed. When a crack-like indication is proven not to be a crack, it may be removed by grinding and the joint completed.

However, any delay to the normal welding cycle arising shall be within the maximum welding time- lapse requirements specified on the WPS.

If the cause of cracking is not immediately identifiable but is considered to be attributable to either the WPS being used or the materials being welded, the manufacturer or contractor shall immediately withdraw the WPS from use and quarantine any suspect material until a definitive cause of cracking is established and corrective action agreed with the Gas Transporter.

13.18 Partially Completed Joints

Whenever possible, joints shall not be left partially completed.

The welding of fittings shall be completed in one heat cycle.

The welding of pipes less than 9 mm wall thickness shall be completed in one heat cycle.

For pipe-to-pipe welds greater than or equal to 9 mm wall thickness, the specific stage when an agreed weld interruption may occur shall be clearly stated on the approved WPS.

Where production conditions are such that pipe-to-pipe welds have to be left partially completed, the following conditions shall apply:

- The thickness of the weld ligament shall be sufficient to support the joint without any deleterious effect. No less than two completed passes shall be accepted.

- Upon discontinuation of welding the joint shall be fully supported and the weld allowed to cool in a slow, uniform manner.

- The movement of partially welded joints shall be subject to the approval of the Gas Transporter. Partially completed welds shall not be moved unless the joint can be fully supported during transportation.

- Prior to recommencement of welding, the joint shall be dry and reheated to within the specified inter-pass temperature range stated in the approved WPS.

13.19 Golden Welds

The sequence of works shall be devised such that the number of golden welds is minimised or eliminated.

When there is no alternative but to include a golden weld, this shall be a pipe-to-pipe configuration.

Unless otherwise agreed by the Gas Transporter, all golden welds shall be completed in one heat cycle and shall not be lowered-off until the full joint has been completed. Final NDT shall not be carried out sooner than 24 hours after weld completion, unless agreed by Gas Transporter.

13.20 Completed Joints

When the final weld run(s) is completed, the joint shall be thoroughly cleaned using hand or power tools. The weld cap shall be visually examined, and any deposition faults or unacceptable defects remedied before the joint is finally allowed to cool below the minimum inter-pass temperature. All weld spatter shall be removed taking care not to damage the component surface in any way.

Grinding or filing may be used to remove excess cap height, or irregular profile which may affect interpretation of radiographic films. However, care and attention shall be taken to ensure that the minimum wall thickness of the pipe, or fitting is not compromised. The finished weld and adjacent pipe/fitting shall not contain any sharp edges or grooves.

The root and cap of set-in fittings, i.e., sweepolets, shall be ground flush with the surrounding parent pipe material prior to inspection. The purpose of this is to aid interpretation of the radiographic films. Care shall be taken to not reduce the overall thickness to below that of the parent pipe.

14 EXAMINATION AND NON-DESTRUCTIVE TESTING OF WELDS

14.1 General

The extent of examination and NDT testing of production welds shall be as specified in Table 22. When datum points are required, the method of marking shall be approved by the Gas Transporter.

Table 22. Examination and Non-Destructive Testing of Production Welds.

Type of Weld	Type of Test	Extent of Testing	Footnotes
Pipe/fitting girth butt welds	Visual	100%	a)
	Radiography or ultrasonic testing	100%	b)
	Surface crack detection (MPI)	100%	a)
Set-on branch attachment with full penetration butt welds (e.g., weldolet)	Visual	100%	—
	Surface crack detection (MPI)	100%	—
Set-in branch attachment with full penetration butt welds (e.g., sweepolet)	Visual inspection	100%	a)
	Radiography or ultrasonic testing	100%	b)
	Surface crack detection	100%	a)
Fillet welds	Visual	100%	—
	Surface crack detection (MPI)	100%	—
	Radiography	1 film	c)
‘Golden Welds’	Visual	100%	—
	Radiography and ultrasonic testing	100%	d)
	Surface crack detection (MPI)	100%	—

Notes:

a) Visual inspection and surface crack detection shall include the internal ‘root’ whenever possible. The manufacturer or contractor shall agree the limits of safe access with the Gas Transporter prior to welding commencing.

b) The primary method and any supplementary method of weld examination shall be agreed with the Gas Transporter. All primary methods of NDT shall have the facility to provide a permanent record of inspection.

c) Radiographic testing is only required when needed to confirm acceptable expansion gap fit-up of socket joints (see 13.5).

d) The primary method and secondary methods of weld examination shall be agreed with the Gas Transporter (see GIS/NDT2).

14.2 Examination of Welds

Each weld shall be examined visually during production and upon completion. This is to ensure compliance with the approved welding procedure specification, to detect unacceptable defects and permit remedial work to be carried out while the joint is still within the original weld cycle inter-pass temperature range.

When access permits, the internal ‘root’ of welds shall be visually inspected.

For small-bore pipework, consideration should be given to the use of a borescope camera to inspect the internal ‘root’ profile and resulting gap with socket welds.

14.3 Non-Destructive Testing of Welds

Upon completion of welding and subject to any agreed time delay, each weld shall be examined by an NDT method approved by the Gas Transporter (see Table 22). Note that if the Gas Transporter requires an alternative time delay prior to the NDT of qualification test welds or production welds this shall be agreed with the manufacturer or contractor prior to welding commencing.

When the Gas Transporter requires additional and supplementary non-destructive testing procedures to be applied to examine final tie-in welds, the manufacturer or contractor and the Gas Transporter shall agree and document the full extent of NDT required before production welding commences. Note that final tie-in welds in some cases may, and in other cases may not, be hydrostatically tested. The supplementary NDT methods to be used to examine welds in the latter category (i.e., golden welds) are specified in GIS/NDT2.

14.4 Non-Destructive Testing Procedures

The manufacturer or contractor shall prepare written NDT procedures and submit them to the Gas Transporter for approval before production welding commences. Approved NDT procedures shall be subject to satisfactory qualification in accordance with GIS/NDT2.

14.5 Qualification of NDT Personnel

All inspection personnel shall be qualified in the appropriate grade for the duties they are to perform (see GIS/NDT2).

15 WELD ACCEPTANCE CRITERIA

15.1 General

The results of all visual inspection and NDT carried out to examine the weld shall be collated and the quality of the joint determined in accordance with the acceptance criteria given in Table 23. Where a higher acceptance standard is required to be applied for the flaw types described in Table 23, this shall be specified by the Gas Transporter in the contract documents.

Engineering critical assessment (ECA) shall not be used to establish acceptance criteria for welds made in accordance with this specification.

15.2 Right of Rejection

The Gas Transporter can reject any weld that appears to meet the weld acceptance criteria specified in Table 23 if, in the opinion of the Gas Transporter, the depth of the flaw is considered detrimental to the weld. In such cases the flaw shall be removed by grinding and repaired in accordance with the approved WPS.

Should a dispute arise between the manufacturer or contractor and the Gas Transporter regarding the depth of a particular flaw in a weld and it is possible to accurately measure the depth of the flaw using a supplementary NDT method then, subject to the approval of the Gas Transporter, the alternative method of measurement shall be employed. In such cases the accurate measurement of the height or depth of a surface breaking or embedded weld flaw shall take into account any inherent sizing error ± values associated with the combined system performance.

Surface-breaking flaws shall not exceed a depth greater than 10% of the pipe thickness, or 1.5 mm whichever is the smaller. Embedded flaws shall not exceed a depth greater than 25% of the pipe thickness, or 3 mm whichever is the smaller.

Branch welds are excluded from these tolerances and defects in these welds shall either be repaired or the whole weld removed.

Any imperfections found on fillet welds shall be assessed to the acceptance criteria specified in BS EN ISO 5817 Quality Level B for pressure containing parts and Quality Level C otherwise.

Table 23. Acceptance Criteria for Welds.

Flaw Type [(a)]		**Acceptance Criteria**
External profile	a	External weld reinforcement shall be uniform, merge smoothly with the parent metal and extend beyond the original preparation by not more than 3 mm on each side. The excess weld metal shall not exceed 3 mm in height. Fillet welds shall be not less than the specified dimensions, regular in form and without undercut.
Internal profile	b	The root bead or any concavity shall merge smoothly into the adjacent surfaces.
Root penetration	c	Not to exceed 3 mm. If service conditions necessitate a more stringent limit this will be specified by the Gas Transporter (see Table 1, item x).
Root concavity	d	Length not to exceed 25% of total length of weld. Depth not to exceed 10% of pipe thickness or 1.5 mm, whichever is the smaller, but at no point shall the weld, including the weld cap, be thinner than the pipe thickness.
Root undercut, Shrinkage groove	e	Length not to exceed 25 mm in any continuous weld length of 300 mm or not to exceed 1/12 of the total length of the weld when this is less than 300 mm. Depth not to exceed 10% of pipe thickness or 1.5 mm, whichever is the smaller. For branch welds this flaw is not permitted.
Incomplete root penetration (single sided welds only) Lack of root fusion (single sided welds only)	f	Length not to exceed 25 mm in any continuous weld length of 300 mm or not to exceed 1/12 of the total length of the weld when this is less than 300 mm. For branch welds this flaw is not permitted.
Cracks	g	Welds having defects 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.
Cap undercut	h	The toes of the weld shall blend smoothly and gradually into the parent metal. Length not to exceed 50 mm in any continuous weld length of 300 mm or not to exceed 1/6 of the total length of the weld when this is less than 300 mm. Depth not to exceed 10% of pipe thickness or 1.5 mm, whichever is the smaller. For branch welds the length shall not to exceed 25 mm in any continuous weld length of 300 mm or not to exceed 1/12 of the total length of the weld when this is less than 300 mm.

Flaw Type [a]		**Acceptance Criteria**
Elongated linear porosity in the root run (hollow bead) Shrinkage cavity Lack of inter run fusion Lack of side fusion Elongated inclusions Parallel elongated inclusions (wagon tracks) Incomplete root penetration, also known as lack of cross penetration (double sided welds only)	i	Length of weld affected by any of these flaws not to exceed 50 mm in any continuous weld length of 300 mm or not to exceed 1/6 of the total length of the weld when this is less than 300 mm. For branch welds the length of weld affected by any of these flaws shall not exceed 25 mm in any continuous weld length of 300 mm or not to exceed 1/12 of the total length of the weld when this is less than 300 mm. Width of elongated inclusions not to exceed 1.5 mm.
Porosity (other than elongated porosity in the root run)	j	Not to exceed a total area when projected radially through the weld of 2% of projected weld area in the radiograph consisting of the length of weld affected by the porosity, with a minimum length of 150 mm, multiplied by the maximum width of the weld. An isolated pore greater than 25% of the pipe thickness or 3 mm whichever is the smaller, in any direction shall be considered unacceptable.
Isolated inclusions (copper, tungsten, or non-elongated slag)	k	Copper inclusions are not permitted. If present, all traces of copper shall be removed and the weld repaired or cut out. The width of other inclusions not to exceed 3 mm or half the pipe thickness, whichever is the smaller. Total length of inclusions not to exceed 12 mm in any continuous length of 300 mm and not more than four inclusions of maximum width in this 300 mm length. Adjacent inclusions shall be separated by a minimum of distance of 50 mm.
Burn-through	l	Not to exceed 5 mm in any dimension and only one in any continuous weld length of 300 mm.
Wormhole	m	Not to exceed 6 mm in length or 1.5 mm in diameter for thicknesses not exceeding 25 mm, or a length of 25% of the thickness or 12 mm, whichever is the smaller, or 3 mm in diameter for thicknesses over 25 mm.
Accumulation of flaws	n	Any accumulation of flaws, except porosity, affecting a total length of 100 mm or more of a weld in any continuous weld length of 300 mm or a total length of 15% or more of the weld length, whichever is the greater, shall not be accepted.

a) For definitions see BS 499-1+ A1.

16 RECTIFICATION OF DEFECTIVE WELDS

16.1 General

Welds shall not be repaired without the approval of the Gas Transporter. The manufacturer or contractor shall record and report to the Gas Transporter all remedial and/or repair welding carried out to each welded joint.

Welds that fail to meet the requirements of clause 15 and 16.4 shall either be repaired locally, or the weld shall be completely removed.

The requirements for qualification of remedial or repair welding procedures for butt welds are given in clause 11.7.8.

16.2 Removal of Defects or Flaws

Defects or flaws in butt or fillet welds shall be removed by chipping, machining, grinding, or gouging, followed by grinding. If air-arc gouging is used, preheating shall be applied prior to metal removal (see clause 13.13.4 and Table 21). When air-arc gouging is used for a full penetration repair, the last 3 mm of the original weld shall be removed by mechanical means, such as grinding.

The weld repair excavation shall be sufficiently deep and long enough to ensure complete removal of the defect or flaw. A gradual taper (e.g., one in one) shall extend from the weld surface to the base of the excavation at each end. The angle or slope of the sides of the excavation shall be in accordance with the approved WPS.

Repairs shall be limited to 30% of the weld length for a partial penetration repair or 20% of the weld length for a full penetration repair. If repairs cannot be completed within the stated tolerances the joint shall be completely removed.

Complete welds shall be removed by mechanised thermal or cold cutting methods, such as machining.

16.3 Re-Welding

Weld repairs shall be carried out in accordance with a written repair welding procedure specification. The welding procedure details contained therein shall be in accordance with the original approved WPS or to a qualified and approved repair WPS.

During production welding, both single weave and multiple pass external weld cap repairs shall match the original weld profile and width and shall be in accordance with the approved WPS.

Repair welding shall only be performed by qualified welders. Separate welder qualification tests may be required for repair welding subject to the limitations of clause 12.

Weld repair shall only be implemented under constant supervision and shall be monitored by the Gas Transporter's and the manufacturer or contactor's representative in accordance with the approved quality plan (see clause 4).

Multiple attempts to repair a weld are not permitted, unless specifically approved by the Gas Transporter (see Table 2).

16.4 Re-Examination of Repair Welds

Weld repair areas shall be subject to at least the same level of inspection as the original weld joint (see GIS/NDT2).

NDT of the repair area shall extend for a minimum of 25 mm from the weld toe on each side of the repaired portion of the joint and beyond each end of the repair excavation.

Surface weld repairs that do not involve re-welding, for example the removal of excessive internal root penetration by grinding, may not require examination by the original NDT method used to establish the presence of the flaw or defect. However, the repair method used to remove the flaw or defect including the

subsequent visual examination and re-measurement to establish acceptance shall be recorded. The Gas Transporter shall approve any proposed repair methods and subsequent re-examination methods prior to production welding commencing.

Should re-examination of the repair area reveal further flaws or defects they shall be evaluated as new flaws or defects in accordance with clause 15.

17 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
- Materials test certificates
- Welding consumable documents
- Preliminary welding procedure specification (pWPS)
- Welding procedure qualification records (WPQR), with contents listed as follows:
    - Index/content sheet
    - Weld procedure approval record (WPAR) front sheet
    - pWPS & WPS
    - Record of welding conditions and parameters
    - Print-outs of welding parameters from data loggers
    - NDT reports
    - Mechanical testing reports
    - Material test certificates
    - Consumable batch certificates
    - Post weld heat treatment details and records (if applicable)
    - Calibration certificates (e.g., for arc data-loggers)
    - Personnel qualification certificates (e.g., for inspector or NDT technician)
- 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; reference is made to the following documents required for the application of this specification. Unless specifically stated, the latest edition shall apply.

External Documents

BS 499-1	–	Welding terms and symbols. Glossary for welding, brazing and thermal cutting.
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 1011-2	–	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels.
BS EN 10204	–	Metallic products. Types of inspection documents
BS EN 12732	–	Gas infrastructure. Welding steel pipework. Functional requirements
BS EN IEC 60974-14	–	Arc welding equipment - Calibration, validation and consistency testing
BS EN ISO 148-1	–	Metallic materials. Charpy pendulum impact test. Test method
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 2560	–	Welding consumables. Covered electrodes for manual arc 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 4063	–	Welding and allied processes. Nomenclature of processes and reference numbers
BS EN ISO 4136	–	Destructive tests on welds in metallic materials. Transverse tensile test
BS EN ISO 5173	–	Destructive tests on welds in metallic materials. Bend tests
BS EN ISO 5178	–	Destructive tests on welds in metallic materials. Longitudinal tensile test on weld metal in fusion welded joints.
BS EN ISO 5817	-	Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levels for imperfections
BS EN ISO 6507-1	–	Metallic materials. Vickers hardness test. Part 1: Test method
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 9015-1	–	Destructive tests on welds in metallic materials. Hardness testing. Hardness test on arc welded joints
BS EN ISO 9016	–	Destructive tests in welds in metallic metals. Impact tests. Test specimen location, notch orientation and examination
BS EN ISO 9017	–	Destructive tests on welds in metallic materials. Fracture test
BS EN ISO 9606-1	–	Qualification testing of welders. Fusion welding. Steels
BS EN ISO 13916	-	Welding — Measurement of preheating temperature, interpass temperature and preheat maintenance temperature
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 14175	–	Welding consumables. Gases and gas mixtures for fusion welding and allied processes
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 15607	–	Specification and qualification of welding procedures for metallic materials. General rules
BS EN ISO 15609-1	–	Specification and qualification of welding procedures of metallic materials. Welding procedure specification. Arc welding
BS EN ISO 15614-1	–	Specification and qualification of welding procedures for metallic materials. Welding procedure test - Arc and gas welding of steels and arc welding of nickel and nickel alloys
BS EN ISO 16834	–	Welding consumables. Wire electrodes, wires, rods and deposits for gas shielded arc welding of high strength steels. Classification
BS EN ISO 17174	–	Welding consumables. Fluxes for submerged arc Welding and electroslag welding. Classification
BS EN ISO 17632	–	Welding consumables. Tubular electrodes for gas shielded and non- gas shielded metal arc welding of non-alloy and fine grain steels
BS EN ISO 17636-1	–	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with film
BS EN ISO 17637	–	Non-destructive testing of welds. Visual testing of fusion-welded joints
BS EN ISO 17639	–	Destructive tests on welds in metallic materials. Macroscopic and Microscopic examination of welds
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 CEN ISO/TR 15608	–	Welding. Guidelines for a metallic materials grouping system

IGEM Documents

IGEM/TD/1	–	The Institute of Gas Engineers & Managers Recommendations on Transmission and Distribution Practice – Steel Pipelines for High Pressure Gas Transmission.
IGEM/TD/13	–	The Institution of Gas Engineers Recommendations on Transmission and Distribution Practice – Pressure regulating installations for Natural Gas, Liquefied Petroleum Gas and Liquefied Petroleum Gas/Air

GIS documents

GIS/B11	–	Carbon and carbon manganese steel bends 200mm nominal size and above produced from pipe by induction bending for operating pressures greater than 7 bar.
GIS/B12	–	Specification for 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	–	Specification for Procurement of Line Pipe for Use in European
	–	Onshore Natural Gas Transmission and Distribution Pipelines
GIS/NDT2	–	Non-destructive testing of welds on construction and fabrication projects
GIS/P2	–	Welding of steel land pipelines designed to operate at pressures greater than 7 bar (supplementary to BS 4515-1)
GIS/P9	–	Specification for the welding of fittings to pipelines operating under pressure (Supplementary to BS 6990)
GIS/P16	–	The dimensions and applications of standard weld end preparations for steel pipe, fittings and valves.
GIS/PW11: Part 1	–	Pipework systems operating at pressures exceeding 7 bar Part 1 – Design and materials
GIS/Q10	–	The sampling of steel pipe and fittings for material testing for pipelines and pipe work designed to operate above 2 bar.
T/SP/PIP/1	–	Specification for steel pipes for pipelines.

Company documents

T/PM/EL/1	–	Procedures for the selection, maintenance and installation of luminaires and lamps

NSAI documents

I.S. 328	–	Gas Transmission Pipelines and Pipeline Installations

APPENDIX B – DEFINITIONS

The definitions applying to this specification are given below

Approved welder:	A qualified welder who has demonstrated competence by producing a test weld or welds that meet the requirements of the welding standard or specification.
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.
Design temperature:	The minimum test temperature required by the designer for weld metal and HAZ impact testing.
Dressing:	Light grinding in the weld area where the parent pipe is not reduced in wall thickness below the minimum allowed in the pipe purchase specification.
Golden weld	A production weld that will not be subject to hydrostatic testing.
Installation:	The fabricated assembly of pipes, fittings and equipment normally situated within a fenced enclosure excluding that which forms part of the pipeline.
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.
Lack of cross penetration:	The un-fused area between an internally applied weld bead and the external passes. Also known as lack of inter-run fusion.
Low hydrogen Process:	For manual welding processes considered to be a diffusible hydrogen content equal to or less than 5 ml/100g 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/100g of deposited weld metal. MIG (131), MAG (135, 136, & 138) and TIG (141) are considered to be low hydrogen processes.
Multi-pass back-weld repair	An internal weld repair consisting of three or more weld runs.
Pipeline:	The extent of all fabrication up to and including block valve assemblies, terminating at the attachment weld to a pig trap as defined
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 authority:	The body or organisation that, through the power vested in it by Government Statute regulates the requirements with which particular pipelines have to comply.
Supply condition:	This term is taken to mean the heat-treated condition of the materials to be welded.
Tie-in weld:	A welded joint that connects two sections of pipe work together in such a manner that direct access to that internal surface of the joint is precluded.
Welding operator:	Person who controls fully mechanised or automatic fusion welding processes.

Workshop: A permanent building or semi-permanent rigid enclosed site structure provided with adequate lifting and handling equipment that has established factory or site welfare facilities available in the immediate vicinity.
This should be able to control the environment in terms of wind, precipitation, temperature and welding fume.

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:

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

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

c) 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. Gas Transporter expectation would be that a time-temperature chart is 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 D.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, and no further action is necessary.

If reading is less than 120 gauss, welding should be possible with AC. 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

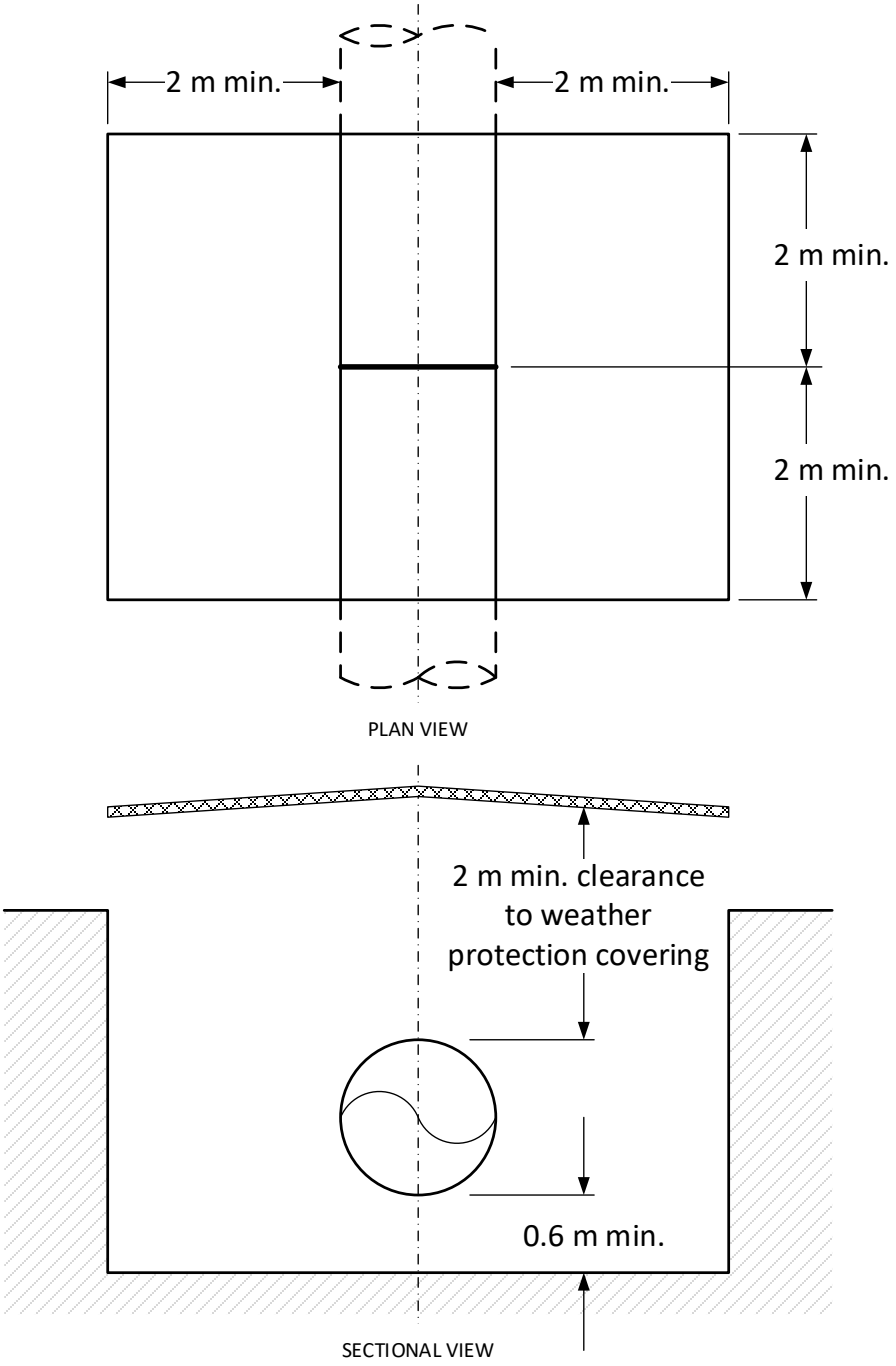
Where the magnetic field still affects the welding arc, but not to the extent that the joint was unweldable, the primary volumetric inspection method shall be supplemented by another volumetric inspection method. For example, if radiographic examination was the primary volumetric inspection method, then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