

Specification for

Welding of Steel Land Pipelines Designed to Operate at Pressures Greater than 7 Barg (Supplementary to BS 4515-1: 2009)

GD/SP/P/2

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Mandatory & Non-Mandatory requirements:

In this document:

Shall: Indicates a mandatory requirement.

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

The Company: Any reference in this document to 'the Company' shall be taken to mean Cadent Gas Limited.

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1. SCOPE

This Specification provides requirements for the welding of steel land pipelines, designed to operate at pressures greater than 7 bar up to and including 100 bar and in accordance with IGEM/TD/1.

This Specification details the requirements for the welding of carbon, carbon manganese and low alloy steel pipelines with specified minimum yield strengths (SMYS) not exceeding 555 N/mm² (i.e. grade L555 or X80) designed in accordance with relevant IGEM documents.

This Specification applies to the welding of pipe, fittings and attachments that comply with the relevant Company specifications given in Table 1 of this specification. It also applies to the welding of pipe or fittings, not manufactured in accordance with the specifications in Table 1, providing that the design and the mechanical and chemical properties of the pipe or fitting comply with one of the specifications listed.

Welding shall be in accordance with BS 4515-1, except where amended by the additional or alternative requirements contained within this specification. All modifications herein shall take precedence over BS 4515-1. The clause references used within this specification relate directly to those in the parent standard BS 4515-1.

2. REFERENCES

This Specification makes reference to the documents listed in Appendix A. Unless otherwise specified, the latest editions of the documents apply, including all addenda and revisions.

3. DEFINITIONS

The definitions applying to this Specification are listed in Appendix B.

4. INFORMATION AND REQUIREMENTS TO BE APPROVED AND DOCUMENTED

4.1 Information to be supplied by the Employer

See Table 2 of this specification.

4.2 Items subject to approval by the Employer

See Table 3 of this specification.

5. EQUIPMENT

In addition to the requirements of BS 4515-1:

The Contractor shall provide calibrated arc monitoring equipment that is independent of the welding plant. It shall be used to record welding process or procedure qualification parameters and for the surveillance of production welding. The equipment shall be made available to the Employers Inspector for monitoring purposes when requested. The carbon equivalent of steels used for the Half Shells and Flanges shall not exceed 0.50% based on ladle analysis, or 0.53% based on product analysis, when calculated using the formula given in method A of BS EN 1011-2 Annex C.

6. MANUFACTURE

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

6.1. Welding process and welding system approval

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

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

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

6.2 Non-destructive testing and destructive testing requirements for welding process and welding system consistency trials

All test welds shall be subject to full non-destructive testing in accordance with GD/SP/NDT/2, and shall meet the requirements of BS 4515-1, Table 9 (as amended by clause 12 of this specification).

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

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

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

7. WELDING CONSUMABLES

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

7.1 General

- When tested in accordance with clause 8.3.2 the weld metal yield strength of welds in pipe material of L555 (or X80) grade shall overmatch the specified minimum yield strength by at least 5%.
- In addition to the requirements of clause 7.1, Note 2 of BS 4515-1, add to the end of the first sentence "and BS EN ISO 18276".

7.2 Storage and Handling

In addition to the requirements of BS 4515-1:

- There shall be no mixing of gases in the field.
- Compressed gases shall only be stored and handled in accordance with industry guidelines and best practice.

- The contractor shall produce a welding consumable storage and handling procedure for approval by the Employer. In addition to the requirements of BS 4515-1, 7.2 and the recommendations of the consumable manufacturers, any special measures identified by the contractor for the storage, handling and 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 Employer, the 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.

8. TESTING, QUALIFICATION AND APPROVAL OF WELDING PROCEDURES

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

8.1 General

Separate procedures shall be provided for any proposed remedial welding. Remedial procedures are those that will be used to correct defects while the production joint is still above the original joint minimum inter-pass temperature. The qualification of remedial welding procedures shall simulate the intended production application. For production welding a record of all remedial welding shall be made.

8.1 k)

Replace existing BS 4515-1 clause 8.1 k with:

In the event of the failure of a specified mechanical test specimen the Employer shall be informed. Subject to meeting the criteria given in Table 6 of this specification and the following requirements, a re-test will be allowed:

- Insufficient original weld material for re-test

Where there is insufficient material available for a re-test, a new test piece shall be produced using the same welding procedure and a replacement specimen or set of specimens for the failed specimen, as appropriate, shall be tested.

- Reason for failure of a test specimen

The reason for the original failure shall be established and reported to the employer. All re-test results shall be reported to the Employer who will determine if the welding procedure can be approved, or whether complete re-qualification of the welding procedure is required.

- Failure of a re-test specimen

If any of the additional test specimens do not comply with the relevant requirements, the proposed welding procedure shall be rejected.

8.1 l)

In addition to the requirements of BS 4515-1:

A calibrated welding arc monitor that provides a printed record shall be used to record the welding parameters of all welding procedure qualification test welds (see 5.0).

8.1.1 Welding procedure test welds (all welding processes)

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

- a) Welding procedure qualification tests shall be carried out on pipe or fittings made from the same material and of the same outside diameter and thickness as that to be used in production. When approved by the Employer, the range of approval specified in clause 8.2 of BS 4515-1 may be applied to qualified welding procedures.
- b) A minimum of two welders shall be used to weld pipe ≥ 457 mm OD.
- c) Minimum pre-heat and weld inter-pass temperatures used in the qualification of a welding procedure test weld shall be in accordance with 10.10.2 of this specification.
- d) Welding electrodes or consumables achieving the low hydrogen requirements of Scale D (as defined by BS EN 1011: Part 2, with ≤ 5 ml of diffusible hydrogen content per 100g of deposited weld metal) shall be used to weld all un-pupped fittings ≥ 914 mm OD (see 10.1 of this specification).
- e) The sequence of joint completion shall be agreed between the Employer and the contractor prior to welding procedure qualification tests commencing.
- f) Where production conditions are such that pipe-to-pipe joints cannot be completed in one welding heat cycle, the welding of the test welds shall simulate the number of heat cycles where the joint has been allowed to cool to ambient temperature before completion.
- g) All fittings shall be welded with a root welded in the vertical-up direction and the weld completed in a single heat cycle. At the discretion of the Employer, for material grades up to and including L450, Induction bends with tangent lengths either side of the bend may be welded in two heat cycles. Induction bends of L555 or X80 grade material shall be welded in one heat cycle.
- h) 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, the welding procedure qualification test shall cover both capping options.

Where both capping options can be accommodated on one test piece, then this shall be permitted, providing that sufficient test material is available to remove all primary mechanical test specimens from the required locations and the additional macro specimens from each welding position covered by the alternative capping option. If insufficient test material is available from the original test joint, then a further test weld shall be produced using the alternative capping option.

The additional macro specimens shall be subject to a hardness survey and macro photograph (see 8.3.2.4 and 8.3.2.5).

- i) Single stringer bead cap repair deposits and single pass internal repair procedures will not be permitted (see j) below).
- j) Qualification of a single pass root bead remedial procedure is permitted for mechanised welding systems using internal welding heads only.
- k) Remedial welding procedures shall be subject to the same qualification and testing requirements as repair procedures.
- l) Repair welds comprising two weld passes only, that are carried out to the internal surface of the original weld joint and that use the same welding process as the original welding procedure, shall be qualified by macro and hardness testing only (see 8.4.3.3 and 8.4.3.4). The test specimens shall be removed from the applicable location shown in Figure 4 b.
- m) Re-repairs, i.e. multiple attempts to repair the same area of a weld shall not be permitted.
- n) When required by the Employer, a retrospective welding procedure qualification test shall be performed between the new and the existing pipe materials that establish a direct connection to an existing pipeline. This test shall be undertaken as soon as the existing pipe material becomes available. The test weld shall be fully tested in accordance with and meet the requirements of this specification.

- o) 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.
- p) Pin brazing of attachment lugs shall not be permitted for new construction projects.
- q) 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.
- r) For horizontal socket joints welding is only permitted using the vertical-up technique (position PF).
- s) Socket fillet weld leg lengths must be equal. The weld profile shall not be concave, i.e. the fillet weld throat thickness must be greater than 0.7 times the leg length.
- t) When ultrasonic testing is applied to manual welds as the primary method of weld inspection before they have cooled to ambient temperature (i.e. below 60°C) and where water is the nominated ultrasonic couplant, the welding procedure qualification test shall include simulation of the water cooling effect.
- u) It may be necessary to produce more than one test weld to accommodate the required mechanical testing. The contractor shall produce sufficient test welds to fully qualify the proposed welding process or procedure in accordance with this specification.

8.1.2 Welding procedure test welds (semi-automatic or mechanised welding systems)

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

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

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

8.1.3 Previously qualified welding procedures

Where a contractor proposes the use of a *previously qualified welding procedure, it shall be offered for the Employer's consideration at contract award stage. The approval or use of a previously qualified welding procedure will be at the sole discretion of the Employer.

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

* That remains valid within the changes affecting approval given in clause 8.2 of BS 4515-1 and as amended by this specification.

8.2 Changes affecting qualification and approval (essential variables)

In addition to the requirements of BS 4515-1:

Add the following clauses:

- 8.2.1 When a welding procedure will be used on existing pipe material, confirmation of the pipe chemical analysis and estimated material grade is required. This may be confirmed through the production of the original mill certificate or by material sampling in accordance with GD/PM/Q/10.
- 8.2.2 L555 (or X80) grade pipe material is supplied to specific manufacturers target chemistry. Where the Employer identifies a significant change in the target chemistry of individual pipe production runs, then additional welding procedure qualification shall be required.
- 8.2.3 The range of approval for set-on fittings shall be as follows:

a) Diameter of set-on fitting

0.5D to 2D where the set-on fitting is 33.4mm OD.

0.5D to 1.5D where the set-on fitting is 60.3mm OD.

0.5D to D where the set-on fitting is 88.9mm OD.

b) Diameter of carrier pipe

0.5D to 2D where the OD of the carrier pipe is ≤ 323.9 mm (no restriction above 323.9mm OD).

c) Nominal wall thickness of test pipe

*Thickness t of line pipe tested	Thickness range of approval		
	Dimensions in millimetres		
	*Steel $R_e \leq 290\text{N/mm}^2$	*Steel $R_e > 290$ to $\leq 360\text{N/mm}^2$	*Steel $R_e > 360\text{N/mm}^2$
$4.8 > t \leq 12.7 t$	4.8 to 12.7	6.4 to 14.3	Not applicable
$12.7 > t \leq 19.1 t$	Not applicable		12.7 to 19.1
$19.1 > t \leq 28.7 t$	Not applicable	Not applicable	14.3 to 28.7
<ul style="list-style-type: none"> Standardised line pipe supplied in accordance with GD/SP/DAT/6 Qualification of a higher yield strength material will cover a lower yield strength material in the same range but not vice-versa. Where more than one thickness of pipe will be used within the yield strength ranges given above, the thicker pipe shall be used to qualify the welding procedure. 			

d) Welding position

The range of approval for the welding position is $\pm 25^\circ$ of the position tested except for position PB according to BS 499-1:2009 which is qualified by position PE, PF or PG.

8.3 Testing of butt welds for procedure qualification**8.3.1 Non-destructive testing**

The test pieces shall be examined as stated in BS 4515-1, 8.3.1 however, the examination techniques used shall be in accordance with GD/SP/NDT/2.

8.3.2 Destructive testing

In addition to the requirements of BS 4515-1:

8.3.2.1 Test specimens

- The macro specimens detailed in Figure 1a and 1b shall be hardness tested in accordance with 8.3.2.5.
- The number of hardness surveys required for non-sour service by Table 3 shall be amended to 2 for ≤ 114.3 mm OD and 3 for > 114.3 mm OD.
- The number of test specimens for destructive testing of repair test welds, where the welding process or procedure is not identical to the mechanised or semi mechanised welding procedure used to make the original joint, shall be as specified in Table 5 of this specification.

8.3.2.2 Transverse tensile test specimens

Transverse tensile testing is not required for butt welds in pipe ≤ 114.3 mm OD.

8.3.2.3 Weld metal tensile testing

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

8.3.2.4 Macro-examination requirements

In addition to the requirements of BS4515-1:

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

BS4515-1 requires that macro test specimens shall be examined at a magnification of x 5. In addition, the degree of photographic magnification used shall be recorded accurately on the test report.

Where L555 (or X80) grade material is examined, a macro specimen shall be removed at the intersection of the pipe seam weld and girth weld location for hardness testing in accordance with 8.3.2.5 of BS 4515-1 and this specification. Where there are two seam welds junctions, the specimen shall be removed from the side of the joint with the highest carbon equivalent percentage.

8.3.2.5 Hardness

In addition to the requirements of BS 4515:1

Hardness surveys shall be carried out on all macro specimens.

8.3.2.6 Impact testing

In addition to the requirements of BS 4515-1:

- a) Charpy impact testing is required for all butt welds in pipe of outside diameter greater than 114.3 mm.
- b) Unless otherwise indicated, the test temperature shall be 0°C for buried pipelines, minus 10°C for pipe-work for use in outdoor ambient conditions, or the actual gas temperature, whichever is the lesser.
- c) Absorbed energy requirements for Charpy impact tests are given in Table 7 of this specification.
- d) For joints greater than 15.9mm NWT, where the welding procedure includes a *combination of welding directions and/or combined welding processes, an additional set of VWT0 and VHT0 Charpy impact specimens shall be taken from within 1mm to 2mm of the outer surface of the pipe and tested.

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

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

**other than the composite procedure where the root pass is welded vertical-up and the remainder of the passes are welded in the vertical-down direction*

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

the need for these tests shall be agreed with the Employer prior to commencing procedure qualification welding.

In addition to the requirements of BS 4515-1:

Add the following clauses:

8.3.2.7 Material toughness testing for fracture mechanics calculations

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

8.3.2.8 Method of Testing for Main Procedure

Where CTOD testing is specified, the extent of testing shall be a minimum of one set of three weld metal centre line specimens and one set of three fusion line specimens cut from the area of highest heat input (usually 180°). For mechanised welding procedures, the minimum additional specimens required for materials toughness testing shall be as given in Table 4 of this specification or shall be as agreed with the Employer prior to welding of the test joint.

CTOD testing of the weld metal and heat affected zone shall be carried out at the minimum design temperature in accordance with BS 7448 under displacement control. The fracture toughness shall be reported in terms of the crack tip opening displacement (CTOD) and the J-integral values. The test specimens shall be cut from the test joint at the locations shown in Figure 1 of this specification. The specimens shall be notched as shown in Figure 3. All-weld tensile specimens shall be cut from the test joint at the location shown in Figure 1 of this specification and shall be prepared and tested in accordance with BS EN 876 and BS EN 10002 Pt 1. The primary purpose of the all-weld tensile test is to enable calculation of fracture toughness to be made.

The Employer will specify any weld procedure acceptance and re-testing criteria.

8.3.2.9 Forged set-on branch attachments

The Company specification GD/SP/PW/11: Part 1 limits the maximum size of a set-on fitting to 88.9 mm OD. The destructive tests required when qualifying a small diameter branch attachment welding procedure e.g. a weld-o-let (within the range 21.3 mm to 88.9 mm OD), shall consist of two macro sections taken 90° apart from each other (one aligned with the pipe axis and one transverse to the skirt of the weld). A hardness survey on both macro sections is required in accordance with BS 4515-1, Figure 8.

8.3.2.10 Forged set-in branch attachments

The destructive tests required for the qualification of the skirt and branch welds of forged set-in branch attachments (i.e. sweep-o-let fittings) shall be agreed with the Employer prior to producing the test welds. As a minimum, testing shall be in accordance with and from the locations shown in Figure 2 of this specification.

8.4 Testing of repair welds for procedure testing

8.4.2 Non-destructive testing

The test pieces shall be examined as stated in BS 4515-1, 8.4.2 however, the examination techniques used shall be in accordance with GD/SP/NDT/2.

8.4.3 Destructive testing

8.4.3.1 General

In addition to the requirements of BS 4515-1:

Where the repair welding process or procedure is not identical to the mechanised or semi-mechanised welding procedure used to make the original joint, the number of test specimens for testing of the repair test weld shall be as specified in Table 5 of this specification.

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

Add the following clause to BS 4515-1:

8.4.3.2 Method of CTOD Testing for Repair Procedures

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

- Group A – Three preferred geometry fracture mechanics specimens with the notch positioned along the centreline of the repair weld as shown in Figure 5 of this specification.
- Group B – Three preferred geometry fracture mechanics specimens with the notch positioned such that the fusion boundary between the repair weld and the original weld intersects the notch tip at the mid-depth position of the repair weld as shown in Figure 6 of this specification.
- Group C – Three preferred geometry fracture mechanics specimens with the notch positioned such that the fusion boundary between the repair weld and the pipe material intersects the notch tip at the mid-depth position of the repair weld as shown in Figure 6 of this specification.
- For repair weld qualification of mechanised welds, the minimum number of CTOD specimens and other tests required shall be as listed in Table 5 of this specification. Any variation to the number of specimens tested shall be agreed with the Employer prior to welding of the test joint.
- The acceptance and re-testing criteria for all repair weld procedures are identical to the requirements of the original welding procedure.
- When material fracture toughness testing of the main procedure is required by the employer for information purposes only, the extent of repair weld CTOD testing may be reduced by agreement.

8.5 Testing of fillet welds for procedure qualification

8.5.1 Non-destructive testing

The test pieces shall be examined as stated in BS 4515-1, 8.5.1 however, the examination techniques used shall be in accordance with GD/SP/NDT/2.

8.5.2 Destructive testing of fillet welds

8.5.2.3 Macro-examination

In addition to the requirements of BS 4515-1:

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

BS 4515-1 requires that Macro test specimens shall be examined at a magnification of x 5. In addition to this, the degree of photographic magnification used shall be recorded accurately on the test report.

9. TESTING, QUALIFICATION AND APPROVAL OF WELDERS

In addition to the requirements of BS 4515-1:

9.1 General

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

9.1.2 Positional Welding

The welder's test shall include the 6 o'clock and 12 o'clock pipe positions or the equivalent positions for the specified categories b and c. Alternatively, at the discretion of the Employer, 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 from 12 o'clock through to 6 o'clock position or the equivalent positions for the specified categories b and c subject to the limitations of 9.1.

Add the following clause to BS 4515-1:

9.1.3 Mechanised welding

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

9.1.4 Non-destructive testing

The test pieces shall be examined as stated in BS 4515-1, 9.6 however, the examination techniques used shall be in accordance with GD/SP/NDT/2.

10. PRODUCTION WELDING

10.1 Proximity of welds

Replace the existing text in BS4515-1 with:

- Adjacent circumferential welds shall be separated by the lesser of one pipe diameter or 750 mm (except where fittings with shorter pipe-pups are used). The Employer shall be informed of any proposed deviation to this requirement and will decide whether the joint may be welded or whether further modification to the pipeline or pipe-work is required to ensure compliance.
- Any fittings (except induction bends with tangent lengths) equal to or greater than 457 mm OD to be used in a pipeline shall have pipe-pups welded to them under fabrication shop conditions before being incorporated into the pipeline. The pup length shall be not less than 250 mm. When space restrictions prohibit fittings with pipe-pups being installed or results in a fitting being welded to a fitting, special care shall be taken with the joint set-up and the application of pre-heat.
- 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.
- Full penetration welds (e.g. forged set-in branches adjacent to circumferential or longitudinal welds) shall normally be not less than 100 mm apart. Should special circumstances require closer proximity, it shall be subject to the approval of the Employer.

Note: Welds should be separated by the maximum possible distance.

The production route shall be planned to ensure that, where necessary, back grinding of root beads and inspection of the weld root is maintained, this is particularly important for fittings (see Table 2 s of this specification). To facilitate welding, repair and inspection, the use of pipe-pups interposed between fittings and branches is desirable.

10.2 Pipe end preparation

In addition to the requirements of BS 4515-1:

The NDT requirements for the ultrasonic testing of cut pipe ends and areas of pipe prepared for welded attachments is specified in clause 10.8 of GD/SP/NDT/2.

10.3 Fusion Faces

In addition to the requirements of BS 4515-1:

Replace the first sentence in BS 4515-1 with:

The contractor shall ensure that the fusion faces on pipes and the adjacent material are free from fins, planar flaws not conforming to clause 12.1, tears, moisture, scale, rust, paint, grease, contamination or foreign matter immediately prior to welding.

Add to the existing text in BS 4515-1:

- Fusion faces not complying with the requirements of clauses 10.2 and 10.3 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 may be acceptable. Heating methods shall not be used.
- Consideration shall be given to providing personnel protection and effective collection and disposal of fumes in all cases where a polyethylene or urethane coating may be heated to temperatures that cause the emission of toxic fumes. Fumes from coating removal and welding can be particularly hazardous in confined spaces.

10.4 Alignment

In addition to the requirements of BS 4515-1:

- No force shall be used to spring or superimpose additional stresses on any component 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.
- Prior to welding commencing the contractor shall submit a method statement for the correction of excessive joint misalignment for approval by the Employer.
- To prevent unacceptable stress concentrations in the weld joint, line up clamps shall be used to support and align the weld joint wherever possible. When the internal root offset, after rotation of the abutting ends to achieve best alignment, is greater than the tolerance range given in Table 8 of this specification, excessive misalignment shall be corrected in accordance with the approved method statement before welding.
- For pipes of different nominal thickness and the same outside diameter, alignment shall be achieved in accordance with GD/SP/P/16.
- For socket joints, the pipe end must be inserted fully into the socket and then withdrawn 2.0 (+ 0.5, - 0) mm as shown in Figure 7 of this specification. 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 10.6 of this specification).
- When required by the Employer 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 Employer or their representative. Alternatively, the joint can be examined by radiography and the original fit-up confirmed.
- For submerged arc welded helical (SAWH) i.e. spiral line pipe, and when joining line pipe to a pre-fabricated fitting short pipe pup piece, the position of the weld seams at the mating faces of adjacent pipes shall be offset by a distance of not less than 100mm.

10.5 Line up clamps and pipe supports

10.5.1 Use of line up clamps

In addition to the requirements of BS4515-1:

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

10.5.2 Removal of pipe supports

In addition to the requirements of BS 4515-1:

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

10.6 Tack welds

In addition to the requirements of BS 4515-1:

- Tack welding (excluding bridge tacks) shall be carried out in accordance with that part of the approved welding procedure that is to be used for the root run. In all cases only qualified welders may carry out tack welding. On diameters equal to or greater than 457 mm OD, at least four equally spaced tack welds, each not less than 50 mm length, shall be used.
- Bridge tack welding may only be carried out when agreed by the Employer. The contractor shall submit a written procedure for the Employers approval, which as a minimum, shall describe the following items:
 - (i) The welding procedure to be used.
 - (ii) The method of bridge tack welding.
 - (iii) The type and size of material to be used as bridging pieces
 - (iv) The pre-heating temperature to be applied before tack-welding.
 - (v) The sequence and method of bridge tack removal.
 - (vi) The maximum diameter of pipe that may be bridge tack welded and then moved to another position or location to complete the weld.
- When the approved welding procedure uses low hydrogen consumables for the fill and cap passes, bridge tacking shall take place using the same type of consumable.
- When socket joints have reached the minimum pre-heat temperature, the assembly may be tack welded in order to maintain alignment during the welding cycle. A minimum of two tack welds must be used, each not less than 12 mm in length. The tack welds must be equally spaced. When welding pipes in the horizontal position, the tack welds must 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.
- Should excessive pipe end magnetism prevent satisfactory weld deposition, the affected pipe or component shall be de-magnetised immediately prior to welding of the joint (see Appendix D of this specification).

10.7 Working clearance

In addition to the requirements of BS 4515-1:

- Excavations shall meet the current statutory and the Company requirements. For recommended dimensions of bell-holes see Appendix E of this specification. Background lighting should be to Table 2 of GD/PM/EL/1, for exterior illumination levels for working areas. Refer to GD/SP/NDT/2 for the required viewing conditions for visual and magnetic particle inspection.

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

10.8 Stray arcs

In addition to the requirements of BS 4515-1:

- In order to reduce the risk of unwanted arc strikes, electrode holders shall be of the fully insulated type.
- Not more than one arc strike per weld may be repaired. Two or more arc strikes will be cause for the complete removal of the weld and damaged pipe material.
- With the prior agreement of the employer in each case, weld deposition repairs to restore pipe wall thickness shall only be carried out using an approved welding procedure. The repaired area shall be examined using complementary NDT methods capable of detecting surface and sub-surface weld defects in any orientation.
- The application of weld deposition repairs is limited to pipe material grade \leq L450 and shall not be carried out on pipe material with a SMYS \geq 485 N/mm². Weld deposition shall not be applied to pipelines that are designed to accommodate pressure cycling or where it could affect the pipeline fatigue life.

10.9 Weather conditions

In addition to the requirements of BS 4515-1:

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

10.10 Preheating and post weld heat treatment

10.10.1 General

In addition to the requirements of BS 4515-1:

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

10.10.2 Preheating

In addition to the requirements of BS 4515-1:

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

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

a) Pipe to pipe joints

- Pipe material \geq L450 (or X65) grade and having a wall thickness greater than or equal to 19.1mm;
 - (i) A minimum preheat temperature of 100°C shall be applied when cellulosic welding procedures are used.
 - (ii) When approved by the Employer, a minimum preheat temperature of 80°C may be applied where the fill and cap passes are deposited using low hydrogen consumables.

- A minimum preheat temperature of 100°C shall be used for pipe material of L555 (or X80) grade regardless of wall thickness.
- For all other pipe grades (< L450 or X65) and wall thickness combinations, a minimum preheat temperature of 50 °C shall be used.

b) Pipe to fitting or fitting to fitting joints

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

c) Socket joint assemblies

- Socket joint assemblies shall not be heated above 150°C care shall be exercised to prevent overheating of the pipe and fitting.
- 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.

d) 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

e) Weld inter-pass temperature

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

10.10.3 Post weld heat treatment temperatures

In addition to the requirements of BS 4515-1:

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

10.11 Branches

In addition to the requirements of BS 4515-1:

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

10.11.2 Spacing of branches

In addition to the requirements of BS 4515-1:

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

10.11.3 Joint preparation

The NDT requirements for the ultrasonic testing of cut pipe ends and areas of pipe prepared for welded attachments is specified in clause 10.8 of GD/SP/NDT/2.

10.12 Inter-run cleaning

In addition to the requirements of BS 4515-1:

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

The cause of any visible cracks or crack-like indications found during welding shall immediately be investigated and reported to the Employer or their Representative. Should a crack be confirmed then the complete joint shall be cut-out and removed. Where a crack-like indication is proved not to be a crack, it may be removed by grinding and the joint completed.

Note: Any delay to the normal welding cycle shall be within the maximum welding time-lapse requirements if specified.

10.13 Partially completed joints

In addition to the requirements of BS 4515-1:

Add the following requirements to item a):

- Unless otherwise agreed by the Employer, the joint shall be completed in the specified heat cycle (see 8.1.1 items e, f, g and q of this specification).
- Any welded joint carried out in a trench or excavation shall have at least 50% of the weld joint thickness completed before being allowed to cool to ambient temperature.
- In excavations, where pipe fabrications are to be joined to a fixed end and the pipe support can only be maintained throughout by mechanical lifting equipment, this joint shall be completed in one welding cycle before being lowering off.

Add the following requirements to item c):

- Any welded joint that will be left partially completed shall be fully supported throughout each production stage i.e. before being allowed to cool to ambient temperature, during re-heating and until the weld is completed. The method of support shall be clearly defined by a method statement and submitted to the Employer for approval.
- Prior to re-heating partially completed welded joints, the joint supports shall be checked to ensure that the support has been maintained. This is required to prevent potential failure and separation of a partially completed weld joint during work as a result of unacceptable stress levels.

11. INSPECTION OF TEST WELDS

11.1 General

In addition to the requirements of BS 4515-1:

Additional or alternative requirements to clause 11.1 of BS 4515-1 are specified in the Company specification GD/SP/NDT/2 and 10.1, Table 2, 4.1 r, 4.1s and Table 3, 4.2z of this specification.

Any additional NDT requirements for tie-in welds that will be hydrostatically tested shall be agreed between the employer and the contractor before production welding commences.

The supplementary NDT methods to be used to examine welds that will not be hydrostatically tested (i.e. golden welds) are specified in GD/SP/NDT/2.

12. ACCEPTANCE AND RECTIFICATION OF WELDS

12.1 Acceptance criteria based on quality control

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

Flaw type		Acceptance criteria
External profile	a	External weld reinforcement shall not exceed 3mm in height
Cracks	g	Welds having defects identified positively as cracks shall be cut out. Crater cracks greater than 5mm in any direction shall be cut out.

		Crater cracks less than or equal to 5mm in any direction shall be removed and repaired or cut out.
Isolated copper inclusions	k	Not permitted. If present, all traces of copper shall be removed, and the weld repaired.

12.1.2 Acceptance criteria

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

12.2 Rectification of welds

12.2.1 Qualifications

In addition to the requirements of BS 4515-1:

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

12.2.4 Re-welding

In addition to the requirements of BS 4515-1:

- Root sealing repair deposits are not permitted (see 8.1 i and 8.4.3 of this specification). For mechanised welding systems that deposit the root bead internally, remedial work may be carried out while the weld inter pass temperature is still above the minimum stated in the approved welding procedure.
- Remedial welding procedures shall be approved by the Employer and qualified on test welds that simulate the type of alternative repair (see 8.1 j and k of this specification). For production welding a record of all remedial welding shall be made.
- During production welding, single woven and multiple pass external weld cap repairs shall match the original weld profile and width (see 8.1.1 h of this specification).

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

13. TABLES

Table 1 – The Company material specifications

Items to be welded	Relevant specification(s)
Bends, Tees, Reducers and End-caps	GD/SP/B/11 GD/SP/B/12
Forgings & Forged components	GD/SP/F/1 GD/SP/B/12
Pipe	GD/SP/PIP/1

Table 2 - Information to be supplied by the Employer (BS 4515-1; 4.1)

The following items are to be supplied by the Employer and shall be fully documented:

	Information (BS 4515-1)	Requirement (GD/SP/P/2)
a)	Whether batch testing of electrodes and filler materials is required (see 7.1).	Batch testing is required when welding steels of minimum specified yield strengths greater than 485 N/mm ² (L485 or X70 grade).
b)	Whether specific compositional controls are to be applied to the deposited weld metal (see 7.1).	Specific compositional control requirements will be contract specific.
c)	The degree of yield strength overmatching for welds in pipe materials where installation methods involve plastic deformation of the pipe or for welds in grade L555 pipe (see 7.1).	For L555 (or X80) pipe material grade the deposited weld metal yield strength shall overmatch the SMYS of the parent material by at least 5%. Any other additional requirements will be contract specific.
d)	Whether different batches of electrodes and filler materials are to be individually identifiable and completely separated (see 7.2).	For L555 (or X80) pipe material grade the individual batches shall be identifiable and completely separated.
e)	The type and number of re-tests required in the event of failure (see 8.1 k).	In the event of failure of any of the mechanical tests, retests may be permitted at the Employers discretion. (see 8.1 k of this specification).
f)	Whether an alternative location is specified for the excavation location for the repair weld test (see 8.4.1).	Alternative locations are not required.
g)	Whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe reeling (see 8.1i).	Not applicable to land pipelines.
h)	Whether specimens should be allowed to	Any alternative duration will be contract specific.

	cool for durations other than 24 hours before testing (see 8.1g).	
i)	The method of weld tensile testing when a minimum weld metal yield strength requirement is specified (see 8.3.2.3).	All-weld tensile specimens shall be prepared and tested in accordance with BS EN 876 and EN 10002 Pt 1.
j)	The number and location of transverse tensile test specimens required for welding procedure testing on pipes up to and including of 114.3mm diameter (see 8.3.2.1).	Transverse tensile testing is not required for butt welds in pipe of outside diameter \leq 114.3 mm (see 8.3.2.2 of this specification).
k)	Whether Charpy impact tests are required for welding procedure approval of butt joints (see 8.3.2.1)	Charpy impact testing is required for all butt welds in pipe of outside diameter greater than 114.3 mm (see 8.3.2.6 a) of this specification).
l)	The number and location of test specimens required for Charpy impact tests on pipes of diameter 114.3mm or less (see 8.3.2.1).	Charpy impact testing is not required for butt welds in pipe of outside diameter 114.3 mm or less (see 8.3.2.6 a) of this specification).
m)	Charpy toughness and test temperature for conditions other than pipe and wall thicknesses up to and including 25 mm, minimum design temperatures not lower than -10°C and pipe grades up to L555 (see 8.3.2.6).	The Employer will specify any requirements different to those specified in 8.3.2.6 on a contract specific basis.
n)	Whether additional NDT methods for fillet welds apply (see 8.5.1 b).	No additional methods are required
o)	Whether alternative hardness values to those given in Table 7 are required (see 8.5.2.4).	The hardness limits shall be as specified in BS 4515-1: Table 7.
p)	Whether a proposed change to a welding procedure or equipment requires re-qualification of the welders (see 9.5 i).	Any change in the welding procedure or equipment which, in the opinion of the Employer, makes production of a sound weld more difficult will be cause for re-qualification of the welder.
q)	Whether prevailing weather conditions are such that quality of the completed weld would be impaired (see 10.9).	The Employer will decide, in consultation with the contractor, whether weather conditions are such that work has to cease or whether with adequate weather protection welding can proceed or continue.
r)	The method(s) and frequency of visual inspection and NDT (see 11.1).	Each weld shall be examined visually during production and upon completion to ensure compliance with the approved welding procedure and to detect unacceptable defects. See 10.12 and 11.1 of this specification and also GD/SP/NDT/2: clause 8.1.
s)	Whether completed welds are to be ground (see 11.1).	Welds may be dressed internally or externally to assist inspection and interpretation. Set-in fittings e.g. sweep-o-lets shall have the weld cap and root dressed (internally only where access permits, see 10.1 of this specification).
t)	Whether alternative techniques are to be used for radiographic testing of welded butt joints (see 11.4.1).	An alternative technique to BS EN 1435: 1997 Class B shall not be used without the approval of the Employer.
u)	Ultrasonic testing acceptance criteria	BS 4515-1: Table 9 as amended by clause 12.1.2 of

	(see 11.5.3)	this specification
v)	Whether NDT acceptance criteria are to be based on quality control or engineering critical assessment (see 12.1.1).	An ECA will only be required when specified by the Employer.
w)	Whether the maximum planar defect dimension is to be less than 25 mm (see 12.1.2).	When specified by the Employer.
x)	Whether a more stringent limit for root penetration is required (see Table 9 flaw type c).	When specified by the Employer.
y)	Whether different hardness limits for anode bonding joints are required (see B.2).	The hardness limits shall be as specified in BS4515-1: clause B.2, b.
Note: BS 4515-1 Items z) to jj) refer to clad steels which are outside the scope of GD/SP/P/2		

Table 3 - Items subject to approval by the Employer (BS 4515-1; 4.2)

The following items are subject to approval by the Employer and shall be fully documented:

	Item (BS 4515-1)	Requirement (GD/SP/P/2)
a)	Welding consumables to be used (see 7.1).	Only welding consumables approved by the Employer may be used. All fillet welds shall be welded with low hydrogen electrodes. Cellulosic electrodes shall not be used for the welding of fittings of 914 mm pipe outside diameter and above. For L555 (or X80) grade pipe materials cellulosic electrodes shall only be used for the root and hot pass runs. All subsequent runs shall be completed using low hydrogen welding consumables.
b)	The definition of a batch when batch testing of electrodes and filler materials is required (see 7.1)	For consumables designed to match or exceed the strength of L555 (or X80) grade pipe material, each material cast shall be tested. A BS EN 10204 Type 3.1 certificate, giving the chemical analysis, tensile and Charpy impact properties shall be supplied (see Table 2 a) of this specification).
c)	The tensile strength of weld metals for joints between dissimilar materials if other than that of the higher strength parent metal (see 7.1)	The tensile strength of the higher strength parent material will 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%.
d)	Test weld production on pipes shorter than full length (see 8.1 b).	The Employer will decide whether any deviation can be permitted (e.g. PC welding position).
e)	Use of roll welding (see 8.1 d).	To be approved by the Employer. Roll welding shall be limited to pipe of maximum 219 mm outside diameter.
f)	Use of a test weld for destructive testing or re-welding to the same procedure following	The Employer will decide whether a defective test weld may be used for destructive testing.

	NDT failure (see 8.1 h).	If the failure is due to cracking, the reason for cracking shall be established by the contactor. The results of this investigation shall be submitted to the Employer before attempting to produce another test weld using the original welding procedure.
g)	The type and number of re-tests of a welding procedure when they are permitted (see 8.1 k)	In the event of failure of any of the mechanical tests, retests may be permitted at the Employers discretion. (see 8.1 k of this specification).
h)	Welding procedure qualification test details and welding procedure specification for production welding (see 8.1 l).	To be approved by the Employer prior to production welding commencing.
i)	Any deviations from the ranges given in Table 2 (see Table 1).	The Employer shall review 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.
i)	Simulation of a fillet weld joint using flat plate fillet welds (see 9.4.1b).	Simulation plate fillet welds are permitted.
k)	Alternative methods of NDT for welder test pieces (see 9.6c).	With the prior approval of the Employer, butt weld tests may be examined using MPA ultrasonic testing. Fillet weld tests shall be examined visually and by magnetic particle inspection.
l)	Giving a welder a second opportunity to gain approval (see 9.8).	The Employer 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 (see 9.9)	Records shall be kept for the period of validity. A welder's qualification will remain valid for the period stated in BS 4515-1:9.1 subject to satisfactory performance.
n)	Use of manual thermal cutting for pipe end bevelling and the ability of the operator (see 10.2).	Not permitted.
o)	The blending out by grinding of minor imperfections within the joint preparation area (see 10.2 a).	The blending out of minor imperfections will be at the Employers discretion in each case.
p)	Method of marking datum points on a joint for ultrasonic testing (see 10.2).	See GD/SP/NDT/2: D7.1.
q)	Method of obtaining minimum mis-alignment other than rotation of the pipes (see 10.4).	The contactor shall submit a method statement for approval by the Employer that details how excessive pipe misalignment will be corrected. (see 10.4 of this specification).
r)	Method of alignment of pipes other than internal line-up clamps (see 10.5.1).	Wherever practicable, approved external or internal pipe clamps shall be used (subject to pipe diameter).
s)	The stage at which line clamps are removed (see 10.5.1).	See BS 4515-1: clause 10.5.1.
t)	The stage at which the pipe is lowered onto skids or support is removed for fittings (see	The root bead shall be completed, and any additional reinforcement deposited (if required by

	10.5.2).	the qualified welding procedure) before the pipe is lowered off. All pipe and fittings must be fully supported throughout the welding cycle (see 10.5.2 of this specification).
u)	Repair of places where stray arcs have occurred (see 10.8).	See clause 10.8 of this specification.
v)	Means of applying preheat (see 10.10.2).	To be approved by the Employer prior to use (see 10.10.2 of this specification).
w)	Methods of attaching and removing thermocouples (see 10.10.4).	The methods to be used shall be submitted to the Employer for approval prior to use.
x)	The welding procedure for branch connections where the angle between the main and branch is less than 60° (see 10.11.1).	All branches shall be made with specialised fittings e.g. forged or pressed tees, forged set-in or set-on fittings which preclude the need for a branch / main angle of less than 60°.
y)	Written ultrasonic examination procedure for pipe material around planned cut out (see 10.11.3).	See GD/SP/NDT/2, 10.8. A written procedure shall be submitted to the Employer for approval prior to commencing.
z)	All NDT procedures to be used for inspection and testing (see 11.1).	See GD/SP/NDT/2, 7.1.
aa)	All inspection personnel (See 11.2).	See GD/SP/NDT/2, 6.1. All inspection personnel shall be qualified in the appropriate grade of the BGAS approval scheme for the duties they are to perform.
bb)	The technique in BS EN 1435:1997 +A2 to be used for radiographic examination (see 11.4.1).	See GD/SP/NDT/2, 9.1.2. Alternative techniques shall not be used without the Employers approval.
cc)	Any method for magnetic particle testing to be used at above ambient temperature [see 11.7 a)].	See GD/SP/NDT/2, 12.3. Magnetic particle testing shall be carried out at ambient temperature, unless otherwise agreed by the Employer.
dd)	Any alternative standard to be used for engineering critical assessment (see 12.1.3).	To be specified by the Employer on a project specific basis (see 12.1.3 of this specification).
ee)	Any proposal to repair a weld (see 12.2.1).	See clauses 8.4 and 12.2 of BS 4515-1 and 8.4 and 12.2 of this specification.
ff)	Any alternative limits on repair weld length (see 12.2.1).	Not permitted without the Employers approval.
gg)	Use of root sealing or single run repair deposits (see 12.2.4).	Root sealing and single stringer bead cap repair deposits are not permitted (see 8.1 i and j of this specification).
hh)	More than one attempt at repair (see 12.2.4).	Not permitted.
ii)	The position of the longitudinal seam weld (if applicable) on the sub sea pipeline at the hyperbaric weld location (see annex A).	Not applicable, should the Company build a sub-sea pipeline a specific GD/SP/P/2 Annex A supplement will be issued.
jj)	Joining technique and equipment for brazing or aluminothermic welding of anode	To be approved by the Employer prior to production welding commencing (see 8.1 p of this

	bonding leads (see B.1).	specification).
kk)	Proposed brazing or aluminothermic welding procedure specification (see B.2).	To be approved by the Employer prior to production welding commencing (see 8.1 p of this specification).
Note: BS 4515-1 items ll) to qq) refer to clad steels which are outside the scope of GD/SP/P/2.		

Table 4 - Additional test specimens for procedure approval of mechanised or semi-automatic butt welds

Number of specimens			
All weld tensile ¹	CTOD weld centre line ^{2, 4}	CTOD weld HAZ ^{2, 4}	Macro/ Hardness ³
2	*6	*6	1
1) All weld tensile specimens required for yield strength confirmation and CTOD calculation. 2) CTOD (Bx2B, SENB) tested at the minimum design temperature under displacement control. 3) Macro specimen (and hardness survey) at butt weld and pipe seam weld junction. 4) *The number of CTOD specimens required shall be agreed with the Employer prior to the welding of any test welds.			

Table 5 - Test specimens for procedure approval of repair welds not identical to the original mechanised or semi-automatic welding procedure

Number of specimens							
Type of Weld Repair			Charpy		CTOD ³		Macro & Hardness ²
	All weld tensile	Tensile	Weld	HAZ	Weld centre line	HAZ	
Full Penetration Repair ¹	1	1	3	3	3	3	1
Partial Penetration Repair ¹	1	1	3	6	3	6	1
Internal Root Repair	0	0	0	0	0	0	1
1) For typical locations see Figure 3 and 4. 2) Hardness survey made on macro-examination specimen. 3) The number of CTOD specimens required shall be agreed with the Employer prior to the welding of any test welds.							

Table 6 - Destructive testing of welding procedures – permitted re-tests

Type of test	Failure type	Re-test allowed	Re-testing requirements
Any specimen type	Invalid due to a geometric or volumetric weld imperfection	Yes	Two additional specimens ²
Transverse tensile test All weld tensile test	Failure to meet test requirements	Yes	Two additional specimens ³
One set of Charpy impact test specimens	Failure to meet test requirements	Yes	One additional set of specimens ⁴
Fracture test	Failure to meet test requirements	No	Welding procedure rejected
Macro specimen	Failure to meet test requirements	No	Welding procedure rejected
Hardness survey	Failure to meet test requirements	Yes	Additional hardness survey ⁵

Note 1: General - A retest will be allowed providing that not more than one of the original valid specimens tested fails to meet the requirements.

Note 2: For each invalid specimen, a further two specimens shall be tested. Where three individual specimens comprise a set of specimens and failure is due to an invalid specimen, one additional set of three individual specimens shall be tested.

Note 3: Providing that not more than one of the original valid specimens tested failed to meet test requirements, two additional test specimens shall be taken from a location either side of the failed specimen.

Note 4: Where three individual specimens comprise a set of specimens and a single specimen has failed, one additional set of three individual specimens shall be tested. 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.

Note 5: If 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 reground (or with the approval of the Employer the specimen reversed), re-prepared in accordance with 8.3.2.4 and re-tested.

Table 7 - Charpy impact specimen test requirements

Pipe thickness	Charpy vee-notch specimen size	Minimum Impact energy requirement (J)	
		Individual value	Average value
≥ 12.5 to < 25mm	10mm x 10mm	30	40
≥ 12.5 to < 28mm	10mm x 10mm	45 ¹	56 ¹
≥ 10mm to < 12.5mm ²	10mm x 7.5mm	24	32
≥ 6.3mm to < 10mm	10mm x 5.0mm	21	28
≥ 6.3mm to < 10mm	10mm x 2.5mm	11	15

Requirement for L555 (or X80) grade materials.
For pipe thickness ≥12.5 mm full size specimens shall be used
The sub-sized specimen impact requirements apply only to materials with a SMYS ≤ 448 N/mm².

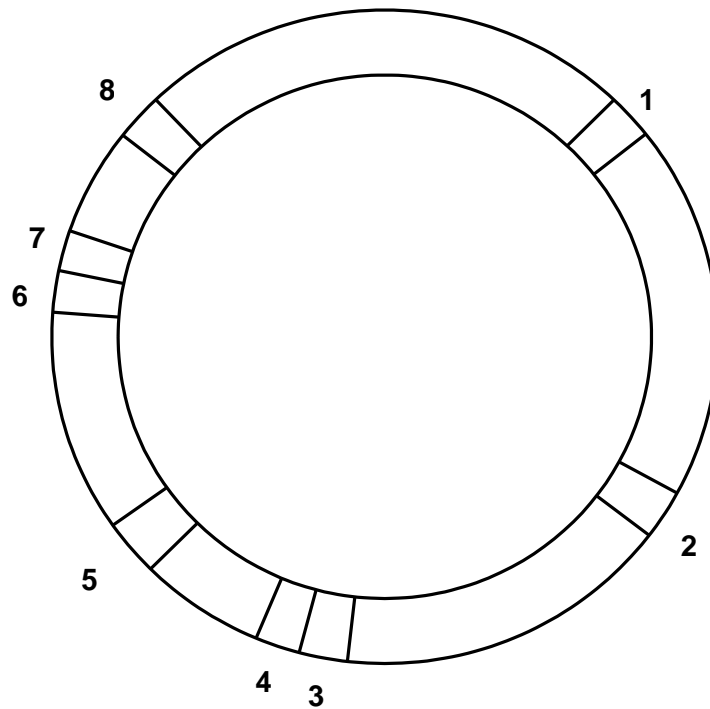
Table 8 - Weld joint alignment tolerances

*Permitted misalignment of abutting surfaces		
Wall thickness	External misalignment	Internal misalignment
T ≤ 10 mm	0.3 x T	1.5 mm around entire circumference
10 mm < T ≤ 24 mm	3.0 mm	2 mm over length DN
T > 24 mm	0.125 x T	2.5 mm over length 1/3 DN

* Unless a lower tolerance is specified by the pipe work designer.
Note: T = Pipe or component thickness. DN = Nominal diameter.

14. FIGURES

Figure 1 - Location of additional test specimens for butt welds made with a mechanised welding process

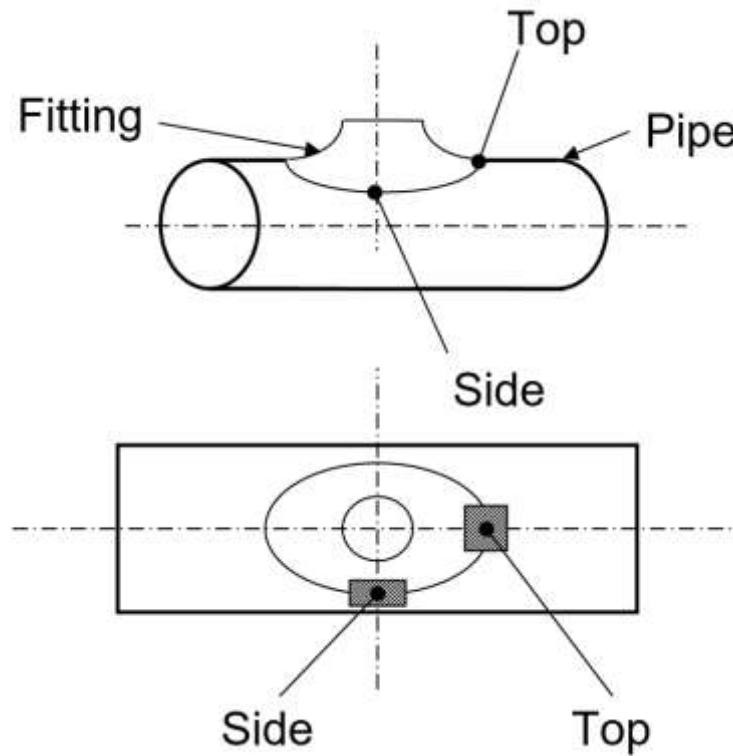


Specimen Location	Position	Mechanical Test
1	45°	All weld tensile
2	Typically, 140°	Set of weld metal Charpy impact tests at -20° C
3	180°	Set of CTOD weld centre line tests
4	180°	Set of CTOD weld heat affected zone tests
5	225°	All weld tensile
6	270°	Set of CTOD weld centre line tests
7	270°	Set of CTOD weld heat affected zone tests
8	Pipe weld seam	Macro and hardness

Notes:

- a) The above specimens represent the minimum requirements and may increase depending on wall thickness and the use of any mixed welding processes.
- b) The Employer will specify the number of CTOD specimens required. As a minimum one set of weld metal and one set of HAZ specimens shall be tested from the area of highest heat input.
- c) The all weld tensile specimens shall be taken from as high up in the weld body as practicably possible without compromising specimen size.
- d) The hardness survey is made on the macro-specimen.
- e) Specimens from location 2 will only be required when batch testing of welding consumables is specified by the Employer.

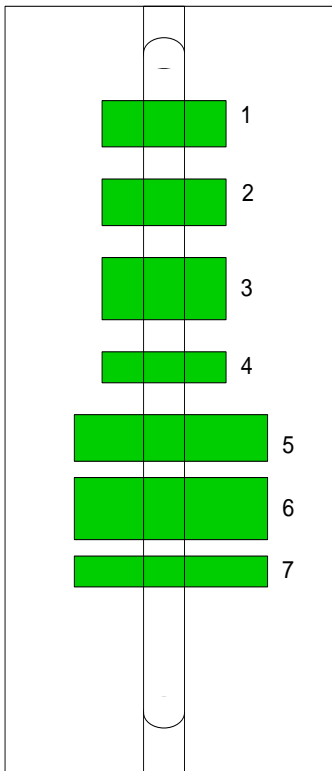
Figure 2 - Location of test specimens for forged set-in branch connections



Location		Specimens
1	Top	Macro and hardness
2		Set of Charpy impact tests, weld metal centre line ^{a, b}
3		Set of Charpy impact tests fusion line pipe side ^{a, b}
4		Set of Charpy impact tests fusion line fitting side ^{a, b}
5		Transverse Tensile (reduced section, if necessary)
6	Side	Macro and hardness
7		Set of Charpy impact tests, weld metal centre line ^{a, b}
8		Set of Charpy impact tests fusion line pipe side ^{a, b}
9		Set of Charpy impact tests fusion line fitting side ^{a, b}
10		Transverse Tensile (reduced section, if necessary)
11		All weld metal tensile specimen ^c

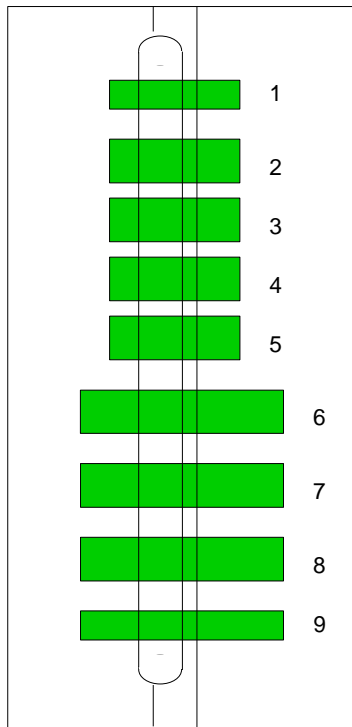
^a Specimens shall be located within 2mm of the root surface of the weld.
^b When the pipe wall thickness exceeds 20mm, 2 additional sets, one weld metal, one fitting HAZ are required at both locations, but taken within 1mm to 2mm of the outside surface of the pipe.
^c When required by the employer (i.e. for fitting material of 555N/mm² SMYS), an all weld metal tensile specimen taken from the side of the sweepolet weld shall be tested in accordance with 8.3.2.3

Figure 3 - Location and number of additional test specimens for full penetration repairs to butt welds made with a mechanized welding process



Specimen	Location
Set of Charpy Tests Weld Metal Centre Line	1
Set of Charpy Tests Weld Fusion Line	2
All Weld Tensile	3
Macro and Hardness	4
Set of CTOD, Weld Centre Line Tests (Fig 1)	5
Set of CTOD, Weld Fusion Line Tests (Fig 1)	6
Tensile	7
<p>Note 1: The minimum requirement may increase depending on wall thickness and the use of any mixed welding process.</p> <p>Note 2: The hardness survey is made on the macro specimen.</p> <p>Note 3: The number of CTOD specimens required may be varied by the Company agreement.</p>	

Figure 4 - Location and number of additional test specimens for partial penetration repairs to butt welds made with a mechanized welding process



Specimen	Location
Macro Hardness	1
Set of Charpy Tests Weld Centre Line	2
Set of Charpy Tests Weld Fusion Line	3
Set of Charpy Tests Weld/Weld Fusion Line	4
All Weld Tensile	5
Set of CTOD Weld Centre Line (Fig 2)	6
Set of CTOD, Weld Fusion Line (Fig 2)	7
Set of CTOD Weld/Weld Fusion Line (Fig 2)	8
Tensile	9
Note 1: The minimum requirement may increase depending on wall thickness and the use of any mixed welding process. Note 2: The hardness survey is made on the macro specimen. Note 3: The number of CTOD specimens required may be varied by the Company agreement.	

Figure 5 - Position of crack tip opening displacement specimen notch for assessing original weld or full penetration repair weld

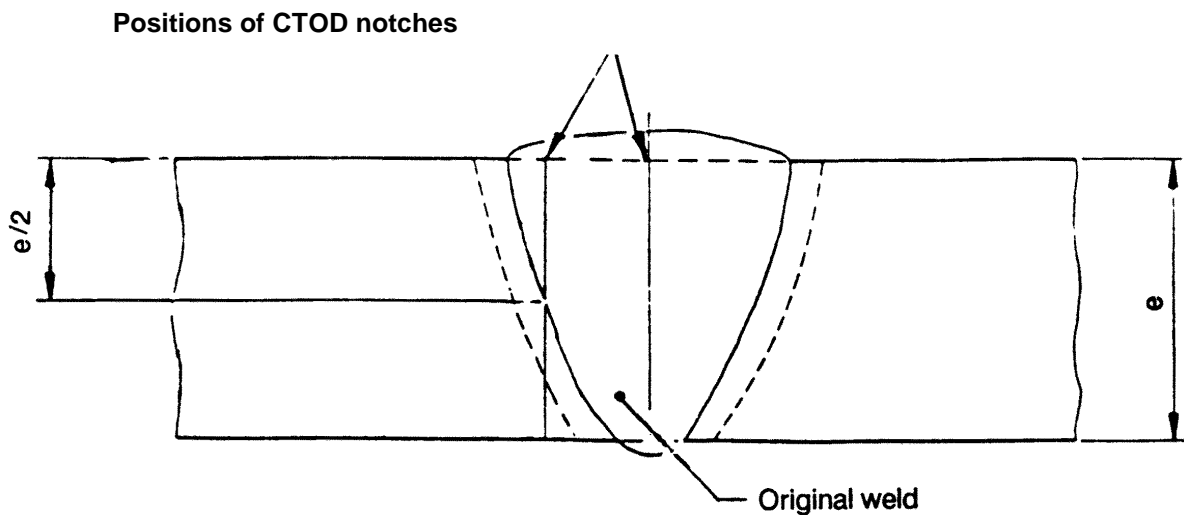


Figure 6 - Position of crack tip opening displacement specimen notch for assessing partial penetration repair weld

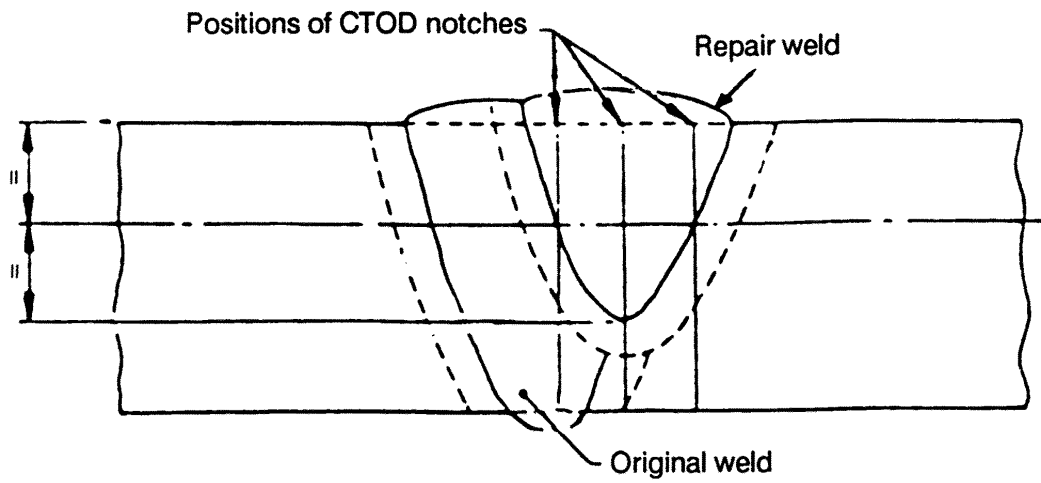
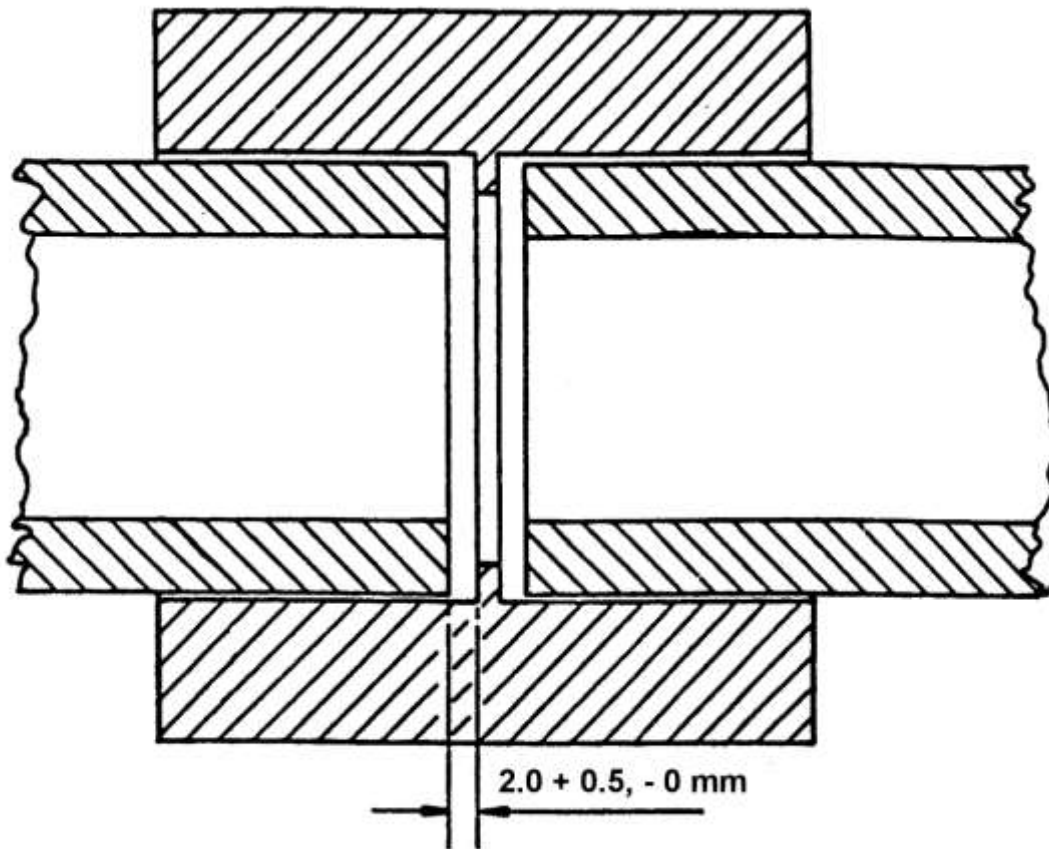


Figure 7 - Configuration required for socket joints prior to welding



APPENDIX A**References**

	British Standards
BS 499-1:2009	Welding terms and symbols Part 1- Glossary for welding, brazing and thermal cutting
BS 499-1	Supplement: 1992 Welding terms and symbols Part 1- Glossary for welding, brazing and thermal cutting – Definitions for electric welding equipment
BS 2633	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: Part 1: Carbon and carbon manganese steel pipelines.
BS 7448-2	Fracture Mechanics toughness tests Part 2. Method for determination of K_{Ic} , critical CTOD and J integral values of welds in metallic materials.
BS EN 876	Destructive tests on welds in metallic materials – Longitudinal tensile test on weld metal in fusion welded joints.
BS EN 895	Destructive tests on welds in metallic materials – Transverse tensile test.
BS EN 1011: Part 2	Welding – Recommendations for welding metallic materials Part 2: Arc welding ferritic steels
BS EN 10002-1	Tensile testing of metallic materials –Part 1: Method of test at ambient temperature
BS EN 10204	Metallic products – Types of inspection documents
BS EN 12732	Gas supply systems – Welded steel pipe work – Functional requirements
BS EN ISO 18276	Welding consumables – Tubular cored electrodes for gas-shielded and non-gas shielded metal arc welding of high strength steels - Classification
	Institution of Gas Engineers and Managers
IGEM/TD/1	Steel Pipelines and Associated Installations for High Pressure Gas Transmission
	Internal Specifications
GD/SP/B/11	Carbon and carbon manganese steel bends 200mm nominal size and above produced from pipe by induction bending for operating pressures greater than 7 bar
GD/SP/B/12	Steel bends, tees, reducers and end caps operating at pressures greater than 7 bar
GD/SP/F/1	Carbon and carbon manganese steel forgings and forged components operating at pressures greater than 7 bar
GD/PM/EL/1	Procedures for the selection, maintenance and installation of luminaires and lamps
GD/PM/Q/10	The sampling of steel pipe and fittings for material testing for pipelines pipe work designed to operate above 2 bar.
GD/SP/P/16	The dimensions and applications of standard weld end preparations for steel pipe, fittings and valves
GD/SP/PW/11: Part 1	Pipework systems operating at pressures exceeding 7 bar Part 1 – Design and materials
GD/SP/NDT/2	Non-destructive testing of welds on construction and fabrication projects
GD/SP/PIP/1	Specification for steel line pipe for natural gas pipelines operating at pressures greater than 7 bar (with specific requirements to BS EN ISO 3183:2012 including Annex M)
	Statutory Instruments
1996 No 825	Pipeline Safety Regulations 1996

APPENDIX B**Definitions and Abbreviations**

	Definitions
Bell-hole	An excavation that permits access to below ground pipe work to facilitate the welding, inspection, coating or any other activity required to conduct the works.
Consistency trials	A series of consecutive welds of repeatable quality made to the satisfaction of the employer, to demonstrate that the proposed welding process or welding system has the technical capability to consistently produce sound welds with the desired metallurgical properties using the approved welding procedure.
Dressing	Light grinding in the weld area where the parent pipe or fitting is not reduced in wall thickness below the minimum allowed by the relevant specification.
Employer	Cadent or its nominated representative
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.
Pipeline	The extent of all fabrication up to and including block valve assemblies, terminating at the attachment weld to a pig trap as defined by the Pipeline Safety Regulations 1996 or as modified by the Employer.
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 the internal surface of the joint is precluded.
	Abbreviations
	<i>For the purpose of this specification the following abbreviations apply</i>
CTOD	Crack tip opening displacement
DN	Nominal diameter
NWT	Nominal wall thickness
OD	Outside diameter
MPA	Manual Phased Array ultrasonic testing
NDT	Non-destructive testing
SMYS	Specified minimum yield strength.

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:
- When the carbon equivalent of the material based on ladle analysis is greater than 0.53.
 - When the pipe thickness is greater than 32 mm.
 - 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.

- C.2** Where residual stresses are to be controlled, it is normally necessary to carry out a stress relieving heat treatment which will involve heating the pipe or component to a temperature within the range 580 °C to 620 °C, maintaining this for a period of time followed by controlled cooling. This heat treatment procedure can take some hours to complete.

Reference should be made to an appropriate standard (e.g. BS 2633) for the details of carrying out such heat treatment.

Where hardness reduction is required, normally a short term tempering procedure is used. This involves rapid heating of the pipe to a temperature higher than 450 °C followed by air-cooling. The extent of this heat treatment should be ascertained by experimental work to ensure that the required properties are achieved for a specific application.

- C.3** The methods of applying heat treatment are:
- Furnace, slow heating and cooling times.
 - Induction coils, rapid through-thickness heating, large power supply needed, narrow band of heating possible.
 - resistance coils, slower heating than induction, very controllable but slower.

APPENDIX D

Pipe End Magnetism

D.1 Introduction

Excessive magnetism at the pipe ends can prevent satisfactory weld deposition; this is particularly so when a magnetic pig has been passed through the line but also may be present in new components.

To overcome this magnetic effect, a number of alternative actions may be carried out, depending upon the strength of the effect.

D.2 Low levels of magnetism

At low levels of magnetism (less than 50 gauss), which probably are sufficient to hold a paper clip to the pipe end, no precautions are usually needed.

D.3 Medium levels of magnetism

At medium levels of magnetism (50 gauss to 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 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 it 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:

a) 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.

b) 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.

c) Step 3

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

d) 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 gaussmeter. 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.

e) 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 s switch off. The current level must drop immediately. Do not reduce current gradually.

f) Step 6

Take gaussmeter reading at the point noted in operation b) above and compare with original reading. If everything has been done correctly, the field should have reduced or reversed. If not, return to operation b) above and repeat operations b), d) and e) above.

g) Step 7

Check the reading and:

- 1) If reading after de-magnetization is less than 50 gauss, welding is possible with dc current - no further action necessary.
- 2) If reading is less than 120 gauss, welding should be possible with ac current. At this stage, there is the choice of either welding with ac or carrying out the procedure in operation h) below.
- 3) 4) If reading is greater than 120 gauss, further de-magnetization is necessary as in operation h) below. If polarity has reversed, return to operation d) above.

h) Step 8

If reading is greater than 400 gauss, repeat operations e), f) and g) above.

If reading is between 120 gauss and 400 gauss, reduce current to 60% and repeat operation e) 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.

i) 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, radiographic examination shall be supplemented with ultrasonic testing.

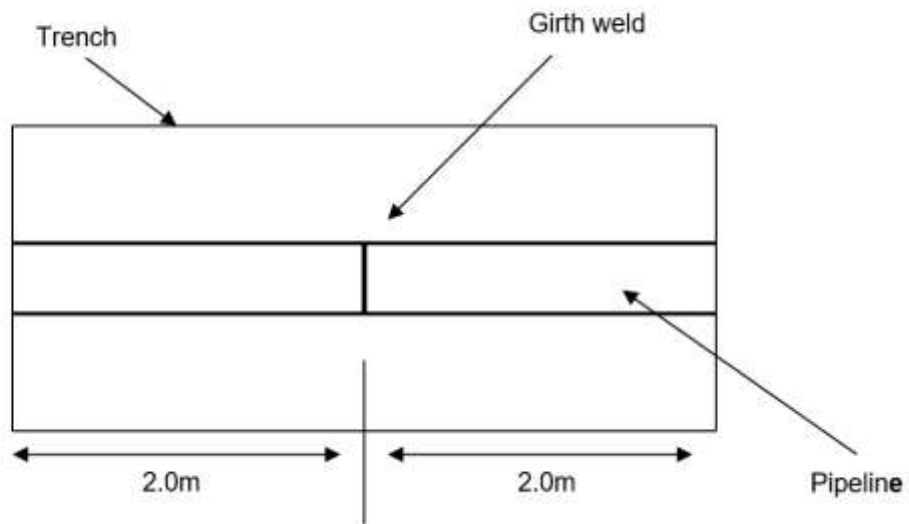
TABLE C.1 - Minimum length of cable required for de-magnetization (de-gaussing)

Pipe OD (mm)	Minimum length of cable (m)*	Pipe OD (mm)	Minimum length of cable (m)*
114.3	5	610	40
168.3	10	762	50
219.1	15	914	60
273.1	20	1067	70
323.9	25	1219	80
457	30	1422	90

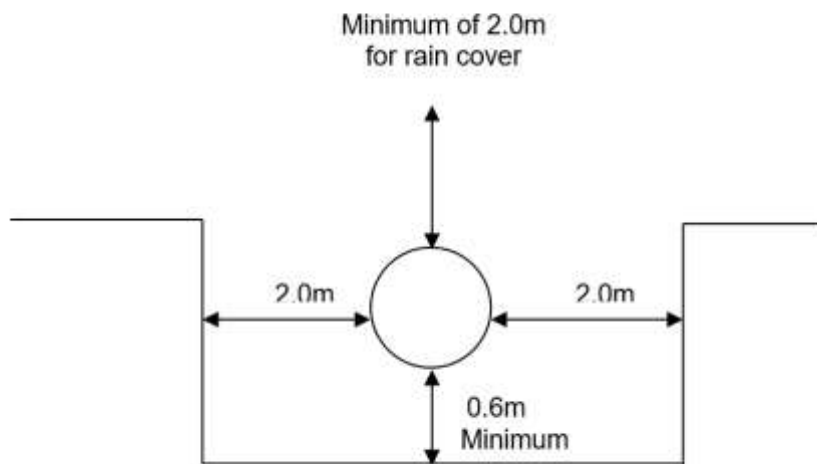
*The above cable lengths refer only to the coils. Additional cable is necessary to connect the coil to the welding generators.

APPENDIX E
Bell-hole Excavation Details

Plan view



Section view



Key Changes

Section	Amendment
All	References updated to current specifications

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