

Specification for

Welding of steel pipelines on land and offshore

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Committees responsible for this British Standard

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- Association of Consulting Engineers
- British Gas plc
- British Institute of Non-destructive Testing
- Engineering Equipment and Materials Users' Association
- Health and Safety Executive
- Institution of Gas Engineers
- International Association of Underwater Engineering Contractors
- Pipeline Industries Guild
- United Kingdom Module Constructors' Association Limited
- United Kingdom Offshore Operators' Association
- Water Services Association of England and Wales
- Welding Institute
- Welding Manufacturers' Association (BEAMA Ltd.)
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Foreword

The revision of this British Standard has been prepared by Subcommittee WEE/21/7. It is applicable to transmission pipelines for gases, liquids or slurries, both on land and offshore. It supersedes BS 4515:1995 which is withdrawn.

If welding in accordance with this British Standard is agreed with a Statutory Authority as a basis for obtaining approval to operate a pipeline, the employer will need to obtain the Authority's agreement to any waivers of requirements. Where this Standard provides for the employer to define requirements, the Authority's agreement may be necessary. Topics commonly involved include selecting the definition of the pipeline's starting and termination points, electing to use hardness limits higher than those in Table 4, selecting the methods and frequency of non-destructive examination, electing to use Engineering Critical Assessment to derive acceptance criteria, permitting multiple attempts at repair, or permitting single run or root repairs. The employer should ensure that all relevant points have been agreed with the Statutory Authority before welding begins.

In reflecting current industry practice, this British Standard places duties on, and allocates powers of approval to, the employer. In this it differs from BS EN 288-3 (under which welding procedure approval may be independent of the employer). Consequently, the term "qualification" has been retained to describe the series of actions which demonstrate that the technical requirements of this British Standard have been met during the process of welding procedure, and welder approval.

It has been assumed, in the drafting of this British Standard, that the execution of its provisions will be entrusted to appropriately qualified and experienced personnel. To ensure compliance with this British Standard, the Contractor's quality systems should normally be in accordance with BS EN ISO 9000.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 48, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1.1 Scope

This British Standard specifies requirements for the welding of carbon, carbon manganese and low alloy steel pipelines with specified minimum yield strengths not exceeding 500 N/mm² and designed in accordance with BS 8010-2 and BS 8010-3.

In addition to the definitive requirements it also requires the items detailed in 1.4 to be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

The standard applies to pipes of outside diameter 21.0 mm and larger having a thickness of 3.0 mm or greater.

1.2 References

1.2.1 Normative references

This standard incorporates, by dated or undated reference, provisions from other publications. These normative references are made at the appropriate places in the text and the cited publications are listed on page 48. For dated references, only the edition cited applies; any subsequent amendments to or revisions of the cited publication apply to this standard only when incorporated in the reference by amendment or revision. For undated references, the latest edition of the cited publication applies, together with any amendments.

1.2.2 Informative references

This standard refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page 48, but reference should be made to the latest editions.

1.3 Definitions

For the purposes of this British Standard, the definitions given in BS 499-1 apply together with the following.

1.3.1

employer

the owner company or the engineering agency in charge of construction

NOTE The employer may act through a consultant, an inspector or other authorized representative.

1.3.2

contractor

the firm undertaking the contract and any subcontractors engaged in work covered by this standard

1.3.3

pipeline

as defined in BS 8010-2 and BS 8010-3

1.3.4

joint

the completed weld joining two sections of pipe, a section of pipe to a fitting, or two fittings

1.3.5

welding procedure¹⁾

a specific course of action followed in welding, including a list of materials and where necessary, tools to be used

1.3.6

welder¹⁾

the operator who performs the welding

1.3.7

approved welder

a welder who has demonstrated his ability to produce welds meeting the requirements of this standard

1.3.8

root-run¹⁾

the first run deposited in the root of a multi-run weld

1.3.9

positional welding

welding wherein the pipe or assembly is held stationary

1.3.10

roll welding¹⁾

a method of manipulation by rotating or rolling pipes or pipe assemblies so that all welding is carried out in or near the flat position

1.3.11

semi-automatic welding¹⁾

welding in which some of the welding variables are automatically controlled, but manual guidance is necessary

1.3.12

mechanized welding¹⁾

welding in which the welding parameters are controlled mechanically or electronically and may be manually varied during welding to maintain the required welding condition

¹⁾ Definition taken from BS 499-1.

1.3.13**sour service**

pipeline design conditions in which a risk of sulfide stress cracking exists

NOTE This is normally assessed using NACE MR0175 [1].

1.3.14**full penetration repair**

any repair from the external surface of the original weld which penetrates to the bore of the pipe

1.3.15**partial penetration repair**

a multi-run repair from the external surface of the original weld which does not penetrate to the bore of the pipe

1.3.16**cap repair**

a single run repair to the external surface of the original weld

1.3.17**internal (back-weld) repair**

any repair from the internal surface of the original weld

1.3.18**re-repair**

a second attempt at repairing a defect in the same location. For qualification purposes this is a full penetration repair, testing a heat-affected zone which has received three full thermal cycles

1.3.19**qualification**

the series of actions necessary to demonstrate that a proposal meets the technical requirements of this British Standard

1.3.20**approval**

formal agreement by the employer that a qualification (or other proposal by the contractor) in accordance with this British Standard is acceptable for the proposed application

1.3.21**preliminary welding procedure specification (pWPS)**

a tentative welding procedure specification, which is assumed to be adequate by the manufacturer, but which has not been approved. Welding of test pieces needed for approval of a welding procedure specification has to be carried out on the basis of a preliminary welding procedure specification (pWPS)

1.4 Information to be supplied and items to be approved**1.4.1 Information to be supplied by the employer**

The following information to be supplied by the employer shall be fully documented and, together with the definitive requirements specified throughout the standard, shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) whether batch testing of electrodes and filler materials is required (see 1.7.1);
- b) whether specific compositional controls are to be applied to the deposited weld metal (see 1.7.1);
- c) whether different batches of electrodes and filler materials are to be individually identifiable and completely separated (see 1.7.2);
- d) whether an alternative location is specified for the excavation location for the repair weld test [see 2.1 b)];
- e) whether specimens should be allowed to cool for a duration other than 24 h before testing [see 2.1 c)];
- f) whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe-reeling [see 2.1 e)];
- g) the type and number of re-tests required in the event of failure [see 2.1 g)];
- h) whether a lower maximum qualified carbon equivalent applies in sour service (see Table 2);
- i) whether any additional methods of non-destructive testing are required of butt joints [see 2.5.1 b)];
- j) the number and location of transverse tensile test specimens required for welding procedure testing on pipes up to and including 114.3 mm diameter (see 2.5.2.1);
- k) whether Charpy impact tests are required for welding procedure approval of butt joints (see 2.5.2.1);
- l) the number and location of test specimens required for Charpy impact tests on pipes of diameter 114.3 mm or less (see 2.5.2.1);
- m) whether alternative hardness values to those given in Table 4 are required (see 2.5.2.4.1 and 2.6.2.4.1);
- n) whether a pipeline is designed for sour service (see Table 4);
- o) whether other values of impact energy apply (see 2.5.2.5.1);

- p) Charpy test temperature and energy requirements for specimens from pipes over 25 mm thick, or with minimum design temperature below -10°C , or strength grades above X65 (see 2.5.2.5.1);
- q) whether additional non-destructive testing (NDT) methods for fillet welds apply (see 2.6.1);
- r) the minimum design temperature (see 2.5.2.5.2);
- s) whether a proposed change to a welding procedure will require requalification of the welders [see 3.5 i);
- t) whether prevailing weather conditions are such that quality of the completed weld would be impaired (see 4.9)²⁾;
- u) the method(s) and frequency of visual inspection and non-destructive testing (see 5.1);
- v) whether completed welds are to be ground (see 5.1);
- w) ultrasonic acceptance criteria (see 5.5.4);
- x) whether automatic ultrasonic testing is to be used (see 5.6);
- y) whether NDT acceptance criteria are to be based on quality control or engineering critical assessment (see 6.1);
- z) whether the maximum planar defect dimension is to be less than 25 mm (see 6.1.2);
- aa) whether a more stringent limit for root penetration is required [see Table 8 c);

1.4.2 Items subject to approval by the employer

The following items which are subject to approval by the employer shall be fully documented and, together with the definitive requirements specified throughout the standard, shall be satisfied before a claim of compliance with the standard can be made and verified:

- a) the tensile strength of weld metal for joints between dissimilar materials if other than that of the higher strength parent metal (see 1.7.1);
- b) consumables to be used (see 1.7.1);
- c) the definition of a batch when batch testing of electrodes and filler materials is required (see 1.7.1);
- d) test weld production on pipes shorter than full length [see 2.1 b)];
- e) explanation for NDT failure if a test weld is to be destructively tested or rewelded to the same procedure [see 2.1 d)];

- f) welding procedure qualification test details and welding procedure specification for production welding [see 2.1 h)];
- g) use of roll welding (see 2.3);
- h) simulation of a fillet weld joint using flat plate fillet welds [see 3.4.1 b)];
- i) alternative methods of NDT for welder test pieces [see 3.6 c)];
- j) giving a welder a second opportunity to gain approval (see 3.8);
- k) all documentation relating to welder qualification tests (see 3.9);
- l) use of manual thermal cutting for pipe end bevelling and the ability of the operator (see 4.2);
- m) method of obtaining minimum misalignment other than rotation of the pipes (see 4.4);
- n) method of marking for ultrasonic testing (see 4.2);
- o) the blending out by grinding of minor imperfections within the joint preparation area [see 4.2 a)];
- p) alternative alignment methods other than internal line-up clamps (see 4.5.1);
- q) the stage at which line-up clamps are removed (see 4.5.1);
- r) the stage at which the pipe is lowered onto skids, or support is removed from fittings (see 4.5.2);
- s) reduction of preheating requirements for tack welds (see 4.6);
- t) repair of places where stray arcs have occurred (see 4.8);
- u) means of applying preheat (see 4.10.2);
- v) methods of attaching and removing thermocouples (see 4.10.4);
- w) the welding procedure for branch connections where the angle between the main and branch is less than 60° (see 4.11.1);
- x) written ultrasonic examination procedure for pipe material around a planned cut-out (see 4.11.3);
- y) all non-destructive testing procedures to be used (see 5.1);
- z) all inspection personnel (see 5.2);
- aa) the technique in BS 2910 to be used for radiographic examination (see 5.4.1);
- ab) any method for magnetic particle testing to be used at above ambient temperature (see 5.7);
- ac) any proposal to repair a weld (see 6.2.1);

²⁾ Information for this item may not be able to be supplied until the appropriate stage of the work is reached.

- ad) any alternative limits on repair weld length (see 6.2.1);
- ae) use of root sealing or single run repair deposits (see 6.2.4);
- af) more than one attempt at a repair (see 6.2.4);
- ag) technique and equipment for brazing or aluminothermic welding of anode bonding leads (see B.1);
- ah) proposed brazing or aluminothermic welding procedure specification (see B.2).
- ai) the position of the longitudinal seam weld (if applicable) on the subsea pipeline at the hyperbaric weld location.

NOTE This information is required in connection with 4.4 for single butt weld tie-ins (see A.9.2).

1.5 Equipment

The contractor shall maintain all welding plant and ancillary equipment in good working order. Welding and cutting plant, instruments, cables and accessories shall conform to the requirements of the appropriate British Standard, e.g. BS 638, BS 679. Pipe handling equipment, rollers and line-up clamps shall be such that they avoid damage or permanent deformation to the pipe and ensure that pipe axes are aligned as specified in 4.4. Their capacity shall be adequate for the welding procedure to be used.

Adequate means of measuring current shall be available, either as part of the welding plant or by the provision of a portable ammeter. In the case of mechanized and semi-automatic welding, means shall be provided for measuring the arc voltage, since this may exert considerable influence on the form, composition and soundness (e.g. porosity) of the weld.

The welding equipment shall be capable of controlling the parameters given in Table 1j to within the limits stated in that table.

NOTE Copper contact tips and backing strips should be checked regularly for damage which could indicate copper contamination of welds.

1.6 Welding processes

The process used shall be a manual, semi-automatic or mechanized arc welding process or combination of processes.

1.7 Welding consumables

1.7.1 General

Electrodes, filler wires and shielding gases, and wire/flux combinations shall produce weld metal that has a tensile strength at least equal to the minimum specified for the parent metal. Moisture content of shielding gases shall correspond to a dewpoint of -30°C or lower.

In the case of joints between dissimilar materials, the weld metal shall have a tensile strength at least equal to that specified for the higher strength parent metal unless an alternative value is approved by the employer.

NOTE 1 Where high transverse strains are expected consideration should be given to requirements for weld metal yield strength.

The chemical composition of the deposited weld metal shall be selected to ensure adequate resistance to degradation from the pipeline contents under the intended operating conditions. The employer shall indicate whether specific compositional controls are to be applied to meet these requirements.

Only consumables which have received the prior approval of the employer shall be used. When required by the employer, batch testing of electrodes and filler materials shall be carried out, in which case the definition of a batch shall be subject to the approval of the employer.

NOTE 2 Appropriate electrodes and filler materials conforming to this subclause are specified in BS EN 499:1995, BS 2493, BS 7084, BS EN 440:1995 and BS 4165. Carbon dioxide used as a shielding gas should conform to BS 4105.

1.7.2 Storage and handling

Different grades and, when specified by the employer, different batches of electrodes and filler materials shall be individually identifiable and completely separated. When the electrode manufacturer recommends that electrodes are stored at a stated temperature, the contractor shall follow such recommendations. The electrodes and filler materials shall be stored and handled at all times during construction so as to avoid damage to them and to the containers in which they are transported. Electrodes, filler wires and fluxes that show signs of damage or deterioration shall not be used. Submerged-arc welding flux shall only be recycled in accordance with the manufacturer's recommendations.

Shielding gases shall be stored in the containers in which they are supplied.

Mixing of gases in the field shall be allowed provided this is an integral part of a mechanized process which utilizes a fail-safe cut-off when the proportions fall outside those specified in the approved welding procedure.

Section 2. Testing, qualification and approval of welding procedures

2.1 General

Testing, qualification and approval of welding procedures shall consist of the following stages.

- a) The proposed welding procedure specifications (pWPS) for the original weld and each of the proposed types of weld repair shall be submitted to the employer for information before the start of test welding.
- b) The test weld shall be produced in accordance with the proposed welding procedure specification under simulated site conditions on full pipe lengths unless otherwise approved by the employer. Repair welds shall be made using a suitably excavated sample of original weld with the excavation located as shown in Figure 1 or as specified by the employer. Any deviations from the pWPS shall be recorded on a modified procedure specification.
- c) The quality of the test welds shall be determined by non-destructive and destructive testing after specimens have been allowed to cool to ambient temperature in simulated site conditions for 24 h unless an alternative duration is specified by the employer.
If water spraying to cool the pipe will be used in production to facilitate rapid inspection, the same conditions shall be simulated in the welding procedure approval.
- d) If non-destructive testing indicates the presence of flaws exceeding the levels permitted in 6.1, the reason for this shall be investigated and explained to the satisfaction of the employer before approval is given for the use of this test piece for the purposes of destructive testing or alternatively for re-welding the test piece to the same details.
- e) When a welding procedure is to be qualified and approved for pipe-reeling, the proposed welding procedure shall include relevant previously-documented strain ageing data and/or any additional tests specified by the employer.
NOTE These tests may include representative strain cycles and accelerated ageing typically for 1 h at 100 °C.
- f) For the procedures to be qualified, the results of the tests on the welds shall show that sound welds having the required mechanical properties can be made using these procedures.
- g) In the event of failure the type and number of such re-tests shall be specified by the employer.
- h) Recorded details for each welding procedure qualification test shall be submitted by the contractor together with the welding procedure specification for production welding to the employer for approval (see 2.2).

NOTE 1 Forms similar to those shown in Annex C should be used.

NOTE 2 When welding procedure qualification tests have been carried out in accordance with this standard and witnessed by an independent inspector, the results may be offered for consideration by other employers provided that the procedure remains valid within the changes affecting approval given in Table 1.

2.2 Records

The details listed in Table 1 for each procedure shall be recorded in the welding procedure qualification record together with the complete results of the procedure tests and certificates for the material and welding consumables.

NOTE Record forms similar to that shown in Annex C should be used. The period for which records should be kept should be specified by the employer.

2.3 Welding procedure

The welding procedure specification shall include those items detailed in Table 1.

NOTE Record forms similar to that shown in Annex C should be used. The period for which records should be kept should be specified by the employer.

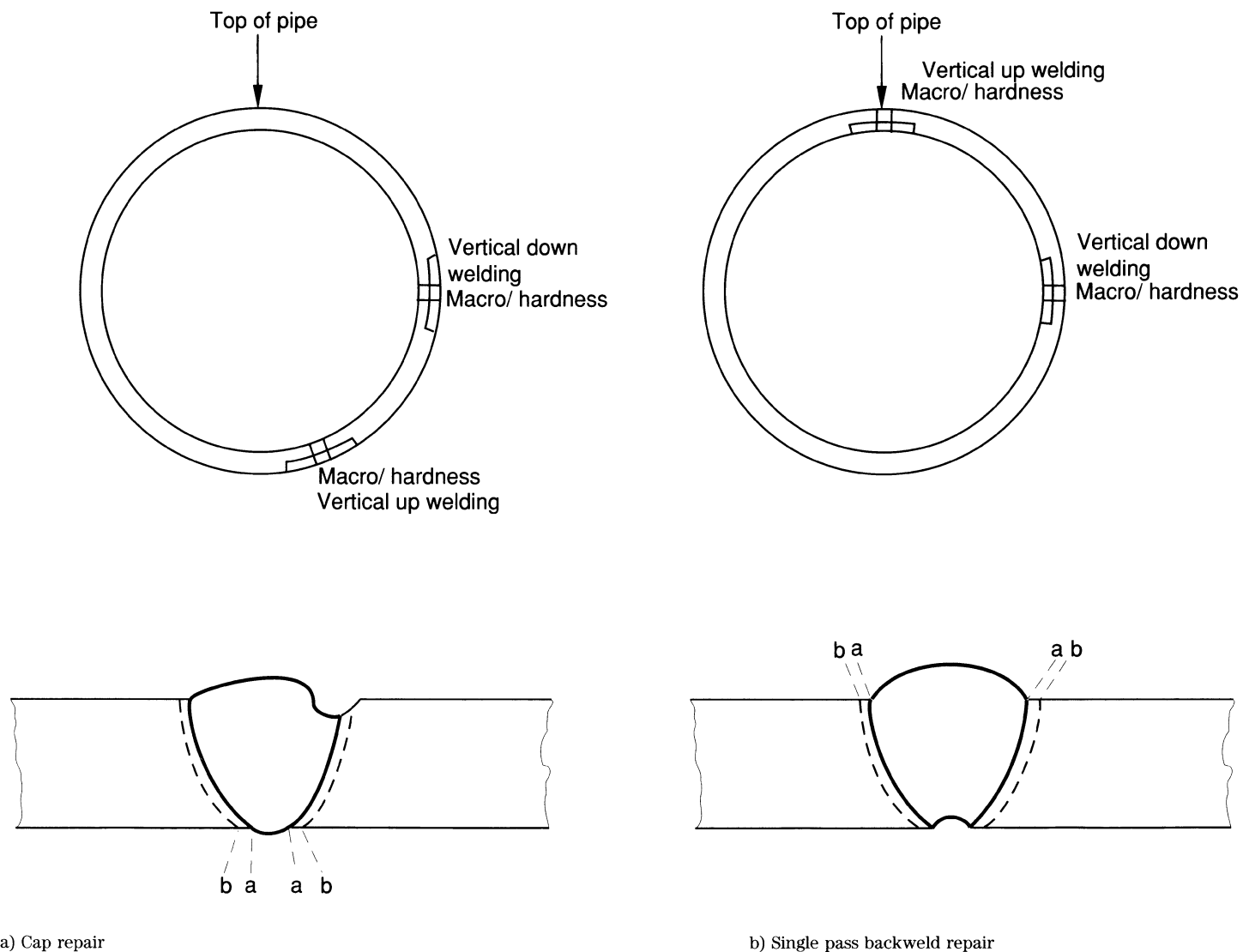
Roll welding shall only be used with the employer's approval and only when it can be demonstrated that the joint can be adequately supported to maintain its axial alignment.

2.4 Changes affecting qualification and approval (essential variables)

When any of the changes given in Table 1 are made to a qualified welding procedure, it shall be regarded as a new welding procedure and as such shall be fully re-qualified. Single run repairs shall require qualification and approval.

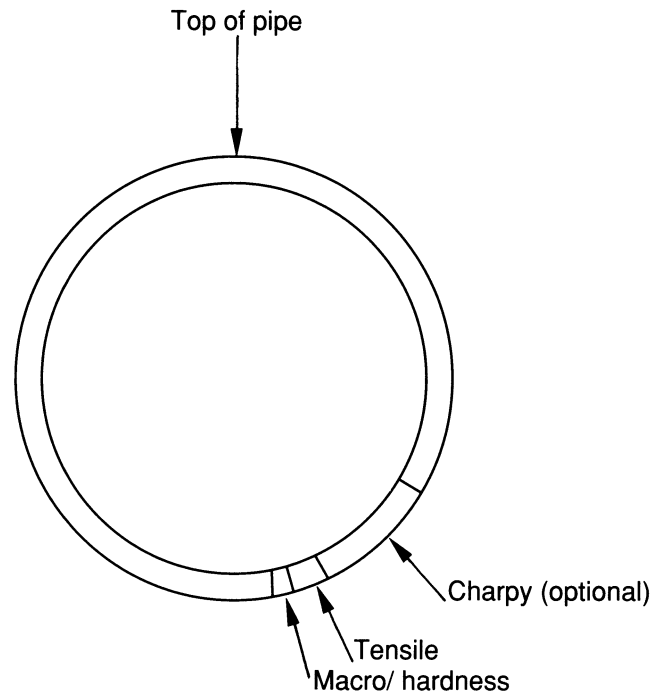
Partial penetration and full penetration repairs shall only require procedure test welding when the pWPS details contain changes affecting the qualification and approval of the original welding procedure as specified in Table 1.

Re-repairs shall only require qualification and approval if Charpy testing is required or if there are changes affecting the approval of the original welding procedure as specified in Table 1.

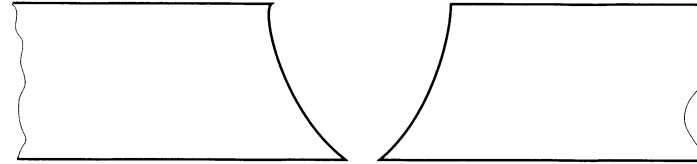


NOTE 1 a original weld fusion line
b original weld heat-affected zone

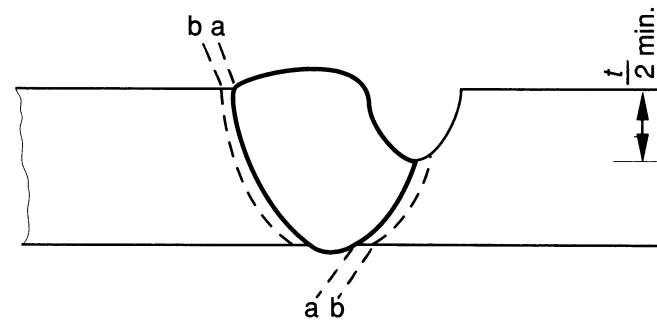
Figure 1 — Location of repair excavations and destructive test specimens



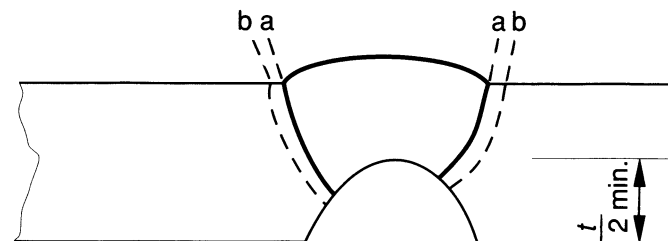
c) Full / re-repair



d) Partial penetration repair



e) Multi-pass backweld repair



- NOTE 1 a original weld fusion line
 b original weld heat-affected zone
 NOTE 2 t wall thickness of test pipe

Figure 1 — Location of repair excavations and destructive test specimens (concluded)

Table 1 — Welding procedure specification details and changes affecting approval

Item		Welding procedure specification details	Changes affecting approval (essential variables)
Welding process	a1	The specific arc welding process (or combination)	A change from one arc welding process to another
	a2	Whether manual, semi-automatic or mechanized	Any change between manual, semi-automatic and mechanized
Base material specification	b1	Specified standard and strength grade	Any change
	b2	Heat treatment condition ^a	Any change
	b3	Composition ^a	A change greater than that permitted by Table 2
Diameter	c	Nominal outside diameter D of pipe	A change outside the range $0.5D$ to $2D$
Thickness	d	Nominal wall thickness t of pipe	A change outside the range $0.75t$ to $1.5t$
Joint configuration (with a sketch, including tolerances)	e	Pipe end preparation including the following:	
	e1	Type of bevel	Any change
	e2	Angle(s) of bevel ^b	Any change outside (unspecified) approved tolerances
	e3	Size of root face ^b	Any change outside (unspecified) approved tolerances
	e4	Width of root gap ^b	Any change outside (unspecified) approved tolerances
	e5	Any use of backing rings	Any addition or deletion, or change of material
	e6	Dimensions ^b of fillet welds	Not restricted as an essential variable
Electrode or filler metal	f	The following information is needed for each run:	
	f1	Nominal diameter of filler/electrode core wire	Any change for the capping layer or the first two layers
			Any increase for other runs
	f2	Trade name	Any change when Charpy testing is required
	f3	Classification	Any change
	f4	Any drying or pretreatment for hydrogen-controlled electrodes	Any relaxation
Number of runs and number of sides welded	f5	Number of wires for each run	Any change
	g1	Number of runs from each side	A change from single to multi-run or vice versa
	g2	Sides welded first and last (double sided welds only)	Any change

Table 1 — Welding procedure specification details and changes affecting approval

Item		Welding procedure specification details	Changes affecting approval (essential variables)
Shielding gas or flux	h1	Choice of shielding gas	Any change in the gas selected
	h2	Composition of any gas mixture	A change exceeding $\pm 10\%$ of the nominal addition in a mixture
	h3	Gas flow rate ^b	Any change exceeding $\pm 10\%$
	h4	Trade name and type of flux	Any change
Electrical characteristics	i	Current (a.c. or d.c.) and polarity	Any change
Welding parameters	j	The following information is needed for each wire size (different values ^b may be used for different runs):	
	j1	Electrical stick-out (SAW, MAG, FCAW) ^b	Any change exceeding ± 5 mm
	j2	Arc voltage ^b	Any change exceeding $\pm 10\%$
	j3	Wire feed speed (SAW, MAG, FCAW) ^b or welding current ^b	Any change exceeding $\pm 10\%$ ($\pm 15\%$ for cellulosic electrodes)
	j4	Travel speed ^b	Any change exceeding $\pm 10\%$
	j5	Calculated value of heat input ^{ab}	No separate restriction
Welding position	k	Angle of pipe axis to the horizontal	Any change exceeding $\pm 25^\circ$
Direction of welding	l	Vertical up, vertical down or horizontal	Any change
Welding technique	m	The following information is needed for each wire size (different values ^b may be used for different runs):	
	m1	Maximum amplitude of any mechanized weave	To be agreed between the contracting parties
	m2	Frequency of any mechanized weave	To be agreed between the contracting parties
	m3	Dwell time at the side of any mechanized weave	To be agreed between the contracting parties
Number of welders	n	Number of root run and of second run welders	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	Any reduction

Table 1 — Welding procedure specification details and changes affecting approval

Item		Welding procedure specification details	Changes affecting approval (essential variables)
line-up clamp	q1	Internal, external, or alternative method (detail)	A change from internal to external, or from clamp to alternative
	q2	Number of runs before removal of clamp	Any reduction
Lowering off (on land), or Barge move-up (offshore)	r	Number of runs before this activity commences	Any reduction
Cleaning of bevel and weld ^a	s	Whether by power driven or hand tools	No restriction
Preheating	t1	Preheat temperature	Any reduction, or an increase exceeding 50 °C
	t2	Method of applying heat	Any change
	t3	Method of controlling temperature	Any change
	t4	Method of measuring temperature	Any change
	t5	Initial temperature of pipe not requiring preheat	Any reduction
	t6	Maximum and minimum interpass temperature for each run	Any change
Post-weld heat treatment ^a	u1	Method of applying heat	Any change
	u2	Soaking temperature	Any change
	u3	Soaking time	Any change
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

NOTE SAW = Submerged arc welding
MAG = Metal active gas
FCAW = Flux-cored arc welding

^a These items shall be specified on the proposed WPS, but are not mandatory for the production WPS if they are controlled through other procedures.

^b These parameters shall be specified as single nominal values on the proposed WPS but as qualified ranges (nominal values $\pm$ permitted variation) on the production WPS. 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.

Table 2 — Qualified ranges of chemical analysis

Element	Value tested	Values qualified ^a
Carbon	Any	Value tested ± 0.04 %
Manganese	Any	Value tested ± 0.25 %
Silicon	Any	Value tested ± 0.20 %
Sulfur	Not over 0.008 %	0 to value tested + 0.015 %
	Over 0.008 %	0.009 to value tested + 0.015 %
Phosphorus	Any	0 to value tested + 0.015 %
Carbon equivalent ^{bc}	Any	Value tested – 0.06 or + 0.03
Aluminium	Not over 0.015 %	Not less than value tested
	Over 0.015 %	Value tested ± 0.030 % but shall be between 0.016 % and 0.060 %
Vanadium	Any	Value tested ± 0.03 %
Nickel	Any	Value tested ± 0.10 %
Copper	Any	Value tested – 0.20 % or + 0.10 %
Chromium	Any	Value tested – 0.10 % or + 0.05 %
Molybdenum	Any	Value tested – 0.10 % or + 0.05 %
Titanium	Any	Value tested ± 0.005 %
Nitrogen	Any	Value tested ± 0.004 %
Calcium	Not over 0.004 %	Not over 0.004 %
	Over 0.004 %	Not over value tested
Niobium	Any	Value tested – 0.02 % or + 0.01 %

NOTE 1 Requalification is required for carbon manganese steels of the same specified minimum yield strength only if the ladle analysis differs from that tested by more than the amounts given in this table. Alternatively the tolerance may be applied to the differences in product analysis.

NOTE 2 The “values qualified” limits for aluminium through to niobium apply only where Charpy testing at temperatures below 0 °C is required, or where the specified minimum yield strength of the pipe exceeds 360 MPa.

NOTE 3 Preliminary welding tests should be considered for pipeline steels with carbon equivalent values > 0.4.

^a For example, for carbon, if value tested was 0.10 % then values qualified are 0.06 % to 0.14 %.

^b Carbon equivalent = $C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$

^c The employer may specify a lower maximum for sour service.