British Standard

BRITISH STANDARD

BS 4515-2:1999

Specification for

Welding of steel pipelines on land and offshore —

Part 2: Duplex stainless steel pipelines

ICS 23.040.10; 25.160.01

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by Technical Committee WEE/21, Pipework welding, to Subcommittee WEE/21/7, Field welding of pipelines, upon which the following bodies were represented:

Association of Consulting Engineers
B G Transco
British Institute of Non-Destructive Testing
Engineering Equipment and Materials Users' Association
Health and Safety Executive
International Marine Contractors' Association
Offshore Contractors' Association
Pipeline Industries Guild
Welding Institute
Welding Manufacturers' Association (BEAMA Ltd.)

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on
15 April 1999

First published October 1969
Second edition March 1984
Third edition September 1995
Fourth edition February 1996
Fifth edition April 1999

The following BSI references relate to the work on this standard:
Committee reference WEE/21/7
Draft for comment 97/713527 DC

ISBN 0 580 28272 4

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

Foreword

This British Standard has been prepared by Subcommittee WEE/21/7. It complements BS 4515-1[1)] which applies only to carbon, carbon manganese and low alloy steels.

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.

Assessed capability. Users of this British Standard are advised to consider the desirability of quality system assessment and registration against the appropriate standard in the BS EN ISO 9000 series by an accredited third-party certification body.

Annex A is informative and annexes B and C are normative.

A British Standard does not purport to include all 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 and ii, pages 1 to 27 and a back cover.

[1)] At time of publication BS 4515:1996.

1 Scope

This British Standard specifies requirements for the welding of solution annealed duplex austenitic—ferritic stainless steel pipelines with specified minimum chromium contents in the range 21.0 % to 26.0 %, designed in accordance with BS 8010.

It is applicable to transmission pipelines for gases, liquids or slurries, both on land and offshore, of outside diameter 21.0 mm and larger, having a thickness of 3.0 mm or greater.

In addition to the definitive requirements it also requires that the items detailed in clause **4** be documented. For compliance with this standard, both the definitive requirements and the documented items have to be satisfied.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of this British Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the publication referred to applies.

BS 499-1, *Glossary for welding, brazing and thermal cutting.*

BS 638 (all parts), *Arc welding power sources, equipment and accessories.*

BS 709, *Methods of destructive testing fusion welded joints and weld metal in steel.*

BS 5650, *Specification for apparatus for gamma radiography.*

BS 8010, *Code of practice for pipelines.*

PD 6493, *Guidance on methods for assessing the acceptability of flaws in fusion welded structures.*

BS EN 169, *Specification for filters for personal eye-protection equipment used in welding and similar operations.*

BS EN 571-1, *Non-destructive testing — Penetrant testing — General principles.*

BS EN 970, *Non-destructive examination of fusion welds — Visual examination.*

BS EN 1435:1997, *Non-destructive examination of welds. Radiographic examination of welded joints.*

BS EN 10045-1, *Charpy impact test on metallic materials. Test method (V- and U-notches).*

BS EN 60974-1, *Arc welding equipment — Part 1: Welding power sources.*

BS EN 60974-11, *Arc welding equipment — Part 11: Electrode holders.*

BS EN 60974-12, *Arc welding equipment — Part 12: Coupling devices for welding cables.*

BS EN ISO 6947, *Welds — Working positions — Definitions of angles of slope and rotation.*

ASTM E3, *Preparation of metallographic specimens.*

ASTM E562, *Test method for determining volume fraction by systematic manual point count.*

ASTM D1193, *Reagent water (Federal Test Method No. 7916).*

3 Definitions

For the purposes of this British Standard, the definitions given in ASTM E562 apply together with the following.

3.1

arc energy

amount of heat generated in the welding arc per unit length of weld (kJ/mm)

NOTE It can be calculated using the following equation:

$$\frac{VI}{w} \times 10^{-3}$$

where

V is the arc voltage (in V);
I is the welding current (in A);
w is the welding speed (in mm/s).

3.2

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

3.3

contractor

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

3.4

employer

owner company or an engineering agency in charge of construction

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

3.5

external repair

any repair from the external surface of the original weld

3.6

full penetration repair

external repair which penetrates to the bore of the pipe

3.7

internal (or back-weld) repair

any repair from the internal surface of the original weld

3.8

joint

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

3.9

mechanized welding

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

3.10

partial penetration repair

multi-run external repair

NOTE A partial penetration repair excavation penetrating to within 6 mm of the bore of the pipe requires a full penetration repair weld qualification.

3.11

pipeline

continuous line of pipes of any length without frequent branches used for transporting fluids

NOTE A pipeline on land is a pipeline laid on or in land, including those sections laid under inland water courses. A subsea pipeline is a pipeline laid under maritime waters and estuaries and the shore below the high water mark.

3.12

positional welding

welding wherein the pipe or assembly is held stationary

3.13

preliminary welding procedure specification (pWPS)

tentative welding procedure specification (WPS) which is assumed to be adequate by the manufacturer, but which has not been qualified or approved

NOTE 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.

3.14

qualification

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

3.15

re-repair

second or subsequent attempt at repairing a defect in the same location

3.16

roll welding

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

3.17

root run

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

3.18

semi-automatic welding

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

3.19

sour service

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

NOTE This is normally assessed using either NACE MR0175 [1] or EFC 17 [2].

3.20

weld zone

region containing the weld metal and heat-affected zone (HAZ)

3.21

welder

operator who performs the welding

3.22

welding procedure

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

3.23

welding procedure specification (WPS)

document providing in detail the required variables for a specific application to ensure repeatability

NOTE An example of a WPS form is given in annex A.

4 Information to be specified and items to be approved

4.1 Information to be specified by the employer

The following information to be supplied by the employer shall be fully documented. For compliance with the standard both the definitive requirements specified throughout the standard and the following documented items shall be satisfied:

a) whether batch testing of electrodes and filler metals is required (see **7.1**);

b) whether different batches of electrodes and filler metals are to be individually identifiable and completely separated (see **7.2**);

c) whether an alternative location is specified for the excavation for the repair weld test (see **8.1**b);

d) whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe-reeling (see **8.1**e);

e) the type and number of re-tests required in the event of a procedure test failure (see **8.1**f)[2)];

f) whether any additional methods of non-destructive testing are required for butt joints (see **8.5.1**b);

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

g) the method and acceptance levels for any hardness tests required (see **8.5.2.4**, **8.6.3** and **8.7.2.4**);

h) whether the proportion of ferrite in the weld and HAZ microstructures is to be determined and the limits that apply (see **8.5.2.5**);

i) whether a temperature lower than the minimum design temperature is to be used as the impact test temperature (see **8.5.2.6.1**);

j) whether corrosion testing is required (see **8.5.2.7** and **8.7.2.7**);

k) whether a proposed change to a welding procedure or equipment will require re-qualification of the welders (see **9.5**i);

l) whether prevailing weather conditions are such that quality of the completed weld would be impaired (see **10.9**)[2)];

m) the method(s) and frequency of visual inspection and non-destructive testing (see **11.1**);

n) whether completed welds are to be ground (see **11.1**);

o) whether NDT acceptance criteria are to be based on quality control or engineering critical assessment (see **12.1**);

p) whether a more stringent limit for root penetration is required (see Table 5c).

q) test variables during pitting corrosion testing of duplex stainless steel (see **C.3** and **C.4.2**).

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) consumables to be used (see **7.1**);

b) the definition of a batch when batch testing of electrodes and filler materials is required (see **7.1**);

c) technique and equipment for attachment of anode bonding leads (see **8.1a**);

d) test weld production on pipes shorter than full length (see **8.1**b);

e) explanation for NDT failure if a test weld is to be destructively tested or re-welded to the same procedure (see **8.1**d);

f) welding procedure qualification test details and WPS for production welding (see **8.1g**);

g) use of roll welding (see **8.3**);

h) alternative methods for ferrite determination (see **8.5.2.5.2**);

i) Charpy V-notch impact testing in the circumferential position (see **8.5.2.6.2**).

j) simulation of a fillet weld joint for welder approval using flat plate fillet welds (see **9.4.1**b);

k) alternative methods of NDT for welder test pieces (see **9.6**);

l) giving a welder a second opportunity to gain approval (see **9.8**);

m) all documentation relating to welder qualification tests (see **9.9**);

n) the blending out by grinding of minor imperfections within the joint preparation area (see **10.2**);

o) method of marking for ultrasonic testing (see **10.2**);

p) method of obtaining minimum misalignment other than rotation of the pipes (see **10.4**);

q) alternative alignment methods other than internal line-up clamps (see **10.5.1**);

r) the stage at which line-up clamps are released (see **10.5.1**);

s) the stage at which the pipe is lowered onto skids, or support is removed from fittings (see **10.5.2**);

t) if tack welds are required, the proposed welding procedure shall be subject to approval by the employer (see **10.6**);

u) repair of pipe material where stray arcs have occurred (see **10.8**);

v) the proposed welding procedure for branch connections where the angle between the main and branch is less than 60° (see **10.11.1**);

w) the ultrasonic examination procedure for pipe material around a planned cut-out (see **10.11.3**);

x) all non-destructive testing procedures to be used (see **11.1**);

y) all inspection personnel (see **11.2**);

z) the technique in BS EN 1435 to be used for radiographic examination (see **11.4.1**);

aa) acceptance criteria for ultrasonic examination (see **12.1.2**);

bb) any proposal to repair a weld (see **12.2.1**);

cc) any repair welds exceeding 20 % of the weld length for full penetration repair or 30 % of the weld length for a partial penetration repair (see **12.2.1**);

dd) all welding procedures for repair welds (see **12.2.3**);

ee) more than one attempt at repair (see **12.2.4**);

ff) use of back-weld repairs (see **12.2.4**).

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 appropriate British Standard where it exists, e.g. BS 638, BS EN 60974-1, BS EN 60974-11, BS EN 60974-12, BS EN 169. All items of equipment including hand tools shall be selected and operated such as to avoid contamination of the weld or pipe surfaces with carbon steel. Pipe handling equipment, rollers and line-up clamps shall be such that they avoid damage, contamination with carbon steel or permanent deformation to the pipe and ensure that the pipe axes are aligned as specified in **10.4**. Their capacity shall be adequate for the welding procedure to be used.

The welding current shall be measured using equipment which is either part of the welding plant or by using 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.

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

6 Welding processes

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

NOTE Manual metal arc welding is not recommended for the root pass of single sided butt welds.

7 Welding consumables

7.1 General

Electrodes, filler wires and shielding gases, and wire/flux combinations, shall produce weld metal that has a 0.2 % proof strength and tensile strength at least equal to the minimum specified for the parent metal. Moisture content of shielding and backing gases shall correspond to a dewpoint of −30 °C or lower.

The chemical composition of the deposited weld metal shall be such as to ensure adequate resistance to degradation from the pipeline contents under the intended operating conditions.

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.

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 be 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.

8 Testing, qualification and approval of welding procedures

8.1 General

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

a) The preliminary 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. The proposed procedure for attachment of anode bonding leads shall also be submitted to the employer for approval.

b) The test weld shall be produced in accordance with the pWPS under simulated site conditions using 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 in Figure 1 or as specified by the employer. Any deviations from pWPS shall be recorded on a modified procedure specification. If forced air or water spraying to cool the weld will be used in production, the same conditions shall be simulated in the welding procedure approval.

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.

d) If non-destructive testing indicates the presence of flaws exceeding the levels permitted in **12.1**, the reason for this shall be investigated and explained to the satisfaction of the employer before approval is given to use this test piece for destructive testing or to re-weld the test piece to the same details.

e) When a welding procedure is to be qualified and approved for pipe-reeling, the proposed welding procedures shall include relevant previously-documented strain ageing data and/or any additional tests specified by the employer.

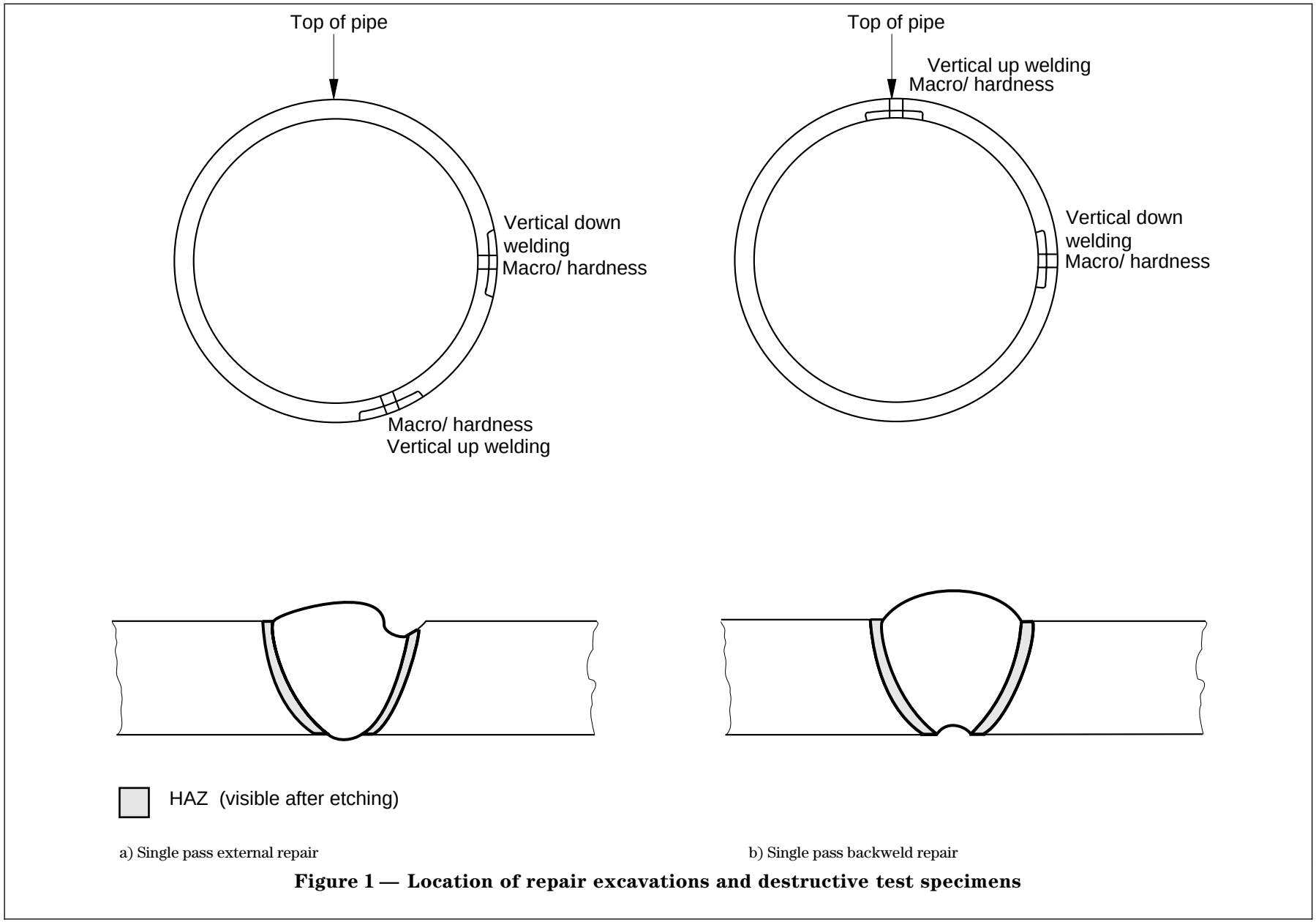
NOTE 1 These tests may include representative strain cycles and accelerated ageing.

f) For the procedures to be qualified, the results of the tests on the welds shall show that sound welds having the required properties can be made using these procedures. In the event of failure, the type and number of such re-tests shall be specified by the employer.

g) The records specified in **8.2** together with the welding procedure specification for production welding shall be submitted by the contractor to the employer for approval (see **8.2**).

NOTE 2 Forms similar to those shown in annex A should be used.

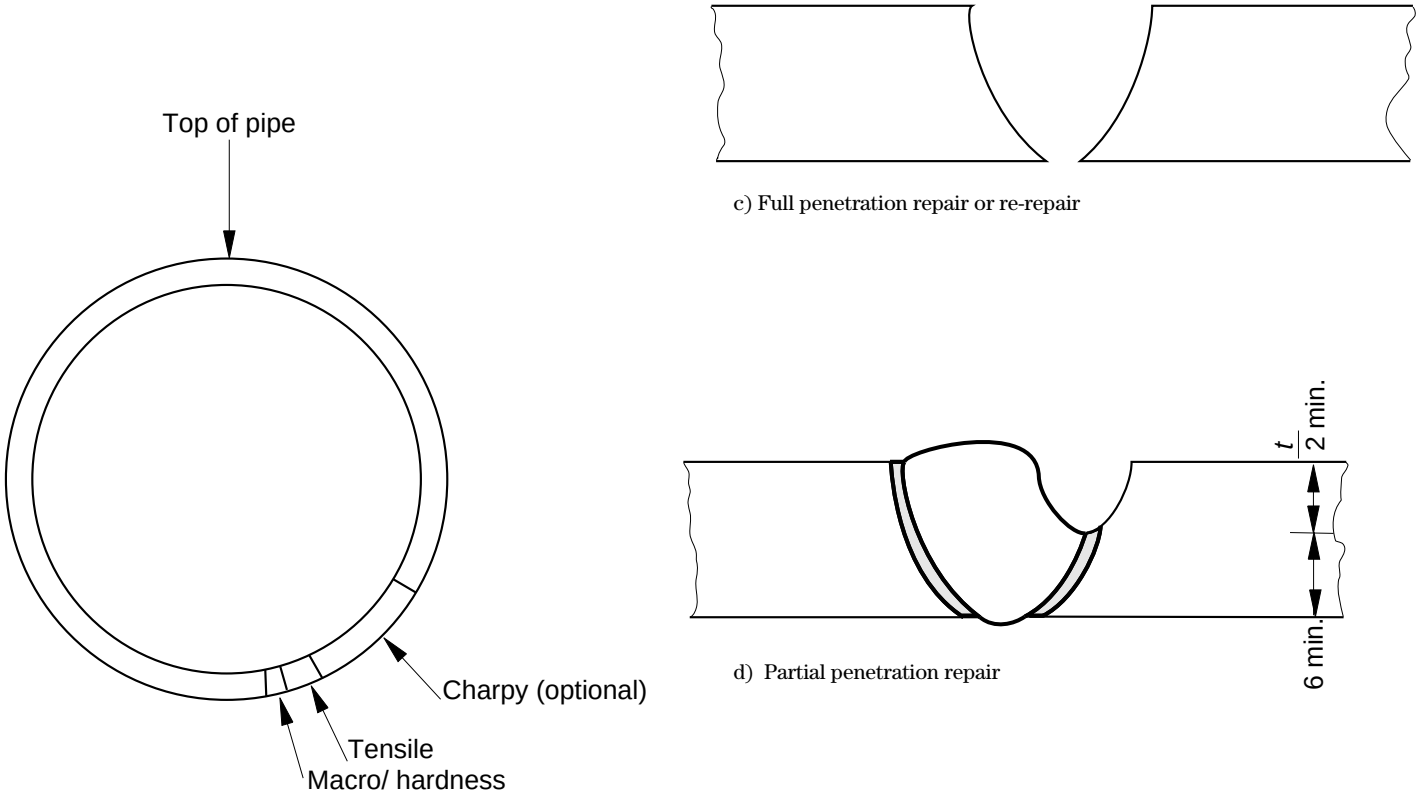
NOTE 3 When welding procedure qualification tests have been carried out in accordance with this standard and witnessed by an independent inspector, the results may be offered for consideration by other employers provided that the procedure remains valid within the changes affecting approval given in Table 1.



a) Single pass external repair

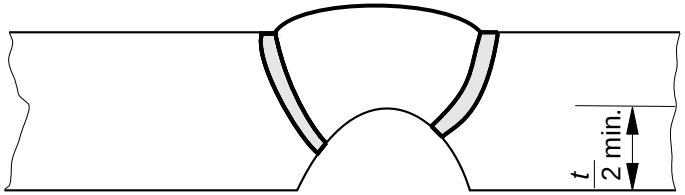
b) Single pass backweld repair

Figure 1 — Location of repair excavations and destructive test specimens



c) Full penetration repair or re-repair

d) Partial penetration repair



e) Multi-pass backweld repair

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
	a3	Whether pulsed arc welding is used	Any change between pulsed and non-pulsed welding
Base material specification	b1	Specified standard and Unified Numbering System (UNS) number	Any change
	b2	Composition[ab] [product analysis for Cr, Mo, W and N]	A change in the pitting resistance equivalent number (PREN) value exceeding −1.5 or +2.5 [where PREN = %Cr + (3.3 × %Mo) + (1.65 × %W) + (16 × %N)]
Diameter	c	Nominal outside diameter "*D*" of pipe	A change outside the range 0.5*D* to 2*D*
Thickness	d	Nominal wall thickness "*t*" of pipe	For t >5 mm, a change outside the range 0.75t to 1.5t but not <5 mm. For $t \leq 5$ mm, a change outside the range t 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[c]	Any change exceeding ±2½°
	e3	Size of root face[c]	Any change exceeding ±0.5 mm
	e4	Width of root gap[c]	Any change exceeding ±33 % of the nominal gap tested
	e5	Any use of backing rings	Any addition or deletion, or change of material
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
	f3	Classification	Any change
	f4	Any drying or pre-treatment for hydrogen-controlled electrodes	Any change outside the manufacturer's recommendations
	f5	Number of wires for each run	Any change
Number of runs and number of sides welded	g1	For both butt and fillet welds, the 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
Shielding gas or flux or backing gas	h1	Shielding gas	Any change in the nominal composition
	h2	Backing gas	Any change in the nominal composition
	h3	Shielding gas flow rate	Any change exceeding ±10%
	h4	Trade name and type of flux	Any change
	h5	Method of monitoring the backing gas oxygen content in the pipe bore	Any change
	h6	Maximum oxygen content of the backing gas in the pipe bore during welding	Any increase
	h7	Number of runs before cessation of backing gas supply	Any reduction

Table 1 — Welding procedure specification details and changes affecting approval *(continued)*

Item		Welding procedure specification details	Changes affecting approval (essential variables)
Electrical Characteristics	i1	Current (a.c. or d.c.) and polarity	Any change
	i2	Pulse frequency in any pulsed welding	Any change exceeding ±10 %
Welding parameters[c]	j	The following information is needed for each wire size. [Different values may be used for different runs]:	
	j1	Electrical stick-out (SAW, MAG, FCAW)	Any change exceeding ±5 mm
	j2	Arc voltage	Any change exceeding ±10 %
	j3	Welding current or wire feed speed (SAW, MAG, FCAW)	Any change exceeding ±10 %
	j4	Background current in any pulsed welding	Any change exceeding ±10 %
	j5	Peak current in any pulsed welding	Any change exceeding ±10 %
	j6	Pulse duration	Any change exceeding ±10 %
	j7	Travel speed	Any change exceeding ±10 %
	j8	Calculated value of arc energy[a]	To be agreed between the contracting parties
Welding position	k	Angle of pipe axis to the horizontal	Any change exceeding ±25°, except that qualification in both the PC[d] and PF[d] positions covers all other welding positions
Direction of welding	l	Vertical up, vertical down, or horizontal	Any change
Welding technique[c]	m	The following information is needed for each wire size [Different values 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
Line-up clamp	n1	Internal, external, or alternative method (give details)	A change from internal to external, or from clamp to alternative
	n2	Number of runs before release (see **4.5.1**) of clamp	Any reduction
Lowering-off (on land), or barge move-up (offshore)	o	Number of runs before this activity commences	Any reduction
Preheat and interpass temperature	p1	Preheat and minimum interpass temperature [°C]	Any reduction
	p2	Maximum interpass temperature [°C]	Any increase
	p3	Method of accelerating weld cooling	Any change

Table 1 — Welding procedure specification details and changes affecting approval *(continued)*

Item		Welding procedure specification details	Changes affecting approval (essential variables)
Repair welds	q1	Repair welding procedure details	Any of the items in this table affecting approval
	q2	Welding procedure details for the weld requiring repair	Any change affecting the approval of the procedure for the weld on which the repair welding procedure was qualified
	q3	Surface from which repair takes place	Any change from external to internal, or vice versa
	q4	Number of attempts at a repair	Any increase
	q5	Number of runs in repair	A change from single run to multi-run or vice versa
	q6	Amount of original weld remaining	A change from complete removal of the original weld metal to partial removal, or vice versa

[a] These items shall be specified on the pWPS, but are not mandatory for the production WPS if they are controlled through other procedures

[b] This requirement only applies when corrosion tests are specified in **8.5.2.7**.

[c] These parameters shall be specified as single nominal values on the pWPS 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.

[d] PA and PF in accordance with EN ISO 6947.

8.2 Records

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

NOTE Forms similar to those shown in annex A should be used. The period for which records should be kept should be specified by the employer.

8.3 Welding procedure

The WPS shall include those items specified in Table 1.

NOTE 1 Forms similar to those shown in annex A should be used.

NOTE 2 The cooling rate controls the austenite/ferrite phase balance in duplex steels and slow cooling can introduce deleterious third phases. Slow cooling is most likely at high arc energy, high interpass temperature and with thin-walled material. For 22 % Cr duplex steel, arc energies above 2.5 kJ/mm are rarely used while 1.5 kJ/mm is a common upper limit for higher alloy duplex steels. Interpass temperatures are also commonly lower for the higher alloy duplex steels.

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.

8.4 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 and submitted for approval, even where the original WPS is used for performing the repair weld.

All repair welding procedures shall be qualified in accordance with **8.7** and submitted for approval.

8.5 Testing of butt joints for procedure qualification

8.5.1 *Non-destructive testing*

All test butt joints shall be examined visually in accordance with BS EN 970 followed by:

a) radiographic examination in accordance with **11.4**; and

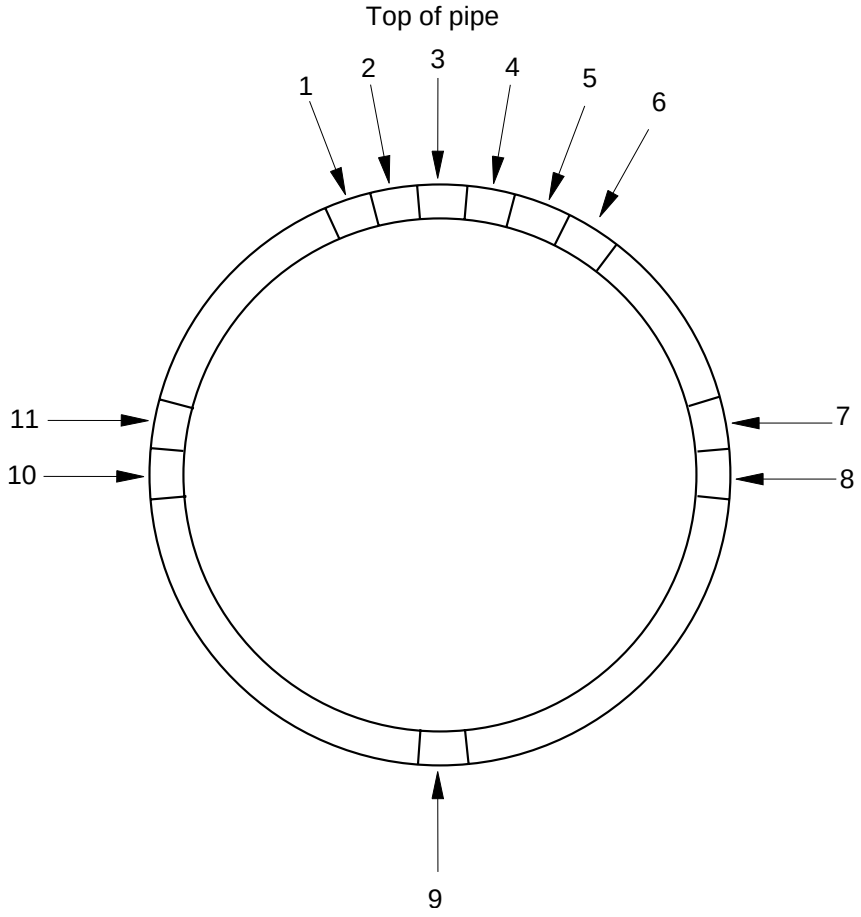
b) any additional method specified by the employer.

The results from visual examination and non-destructive testing shall be assessed according to the appropriate acceptance criteria specified in **12.1**.

8.5.2 *Destructive testing*

8.5.2.1 *Test specimens*

Following acceptance of NDT in accordance with **8.5.1**, test specimens shall be cut from the test joint at the locations shown in Figure 2. The number of specimens and the tests to which they shall be subjected shall be in accordance with Table 2.



Specimen type	Required locations
Macro	1, 9, 10
Tensile	2, 11
Set of weld metal Charpy tests[a]	3, 5[b], 7
Set of fusion line Charpy tests[a]	4, 8, 6[b]

[a] Specimens shall be located within 2 mm of the root surface of the weld.

[b] Additional set for pipe thickness over 20 mm located within 2 mm of the cap surface of the weld.

Figure 2 — Location of test specimens

Table 2 — Number of specimens for procedure qualification tests on butt joints

Test	Number of specimens
Transverse tensile	2
Macro-examination	3
Hardness survey[a] (on macro)	3
Micro-examination[a]	2
Weld root Charpy sets	2
Fusion line root Charpy sets	2
Weld cap Charpy set (for wall thickness >20 mm)	1
Fusion line cap Charpy set (for wall thickness >20 mm)	1
Weld mid-thickness Charpy set (for wall thickness ≥35 mm)	1
Fusion line mid-thickness Charpy set (for wall thickness ≥35 mm)	1
Corrosion test[a]	2

[a] When required by the employer.

8.5.2.2 *Transverse tensile test*

8.5.2.2.1 *Requirements*

When tested as described in **8.5.2.2.2**, the tensile strength of the joint shall be equal to or greater than the specified minimum tensile strength of the pipe material. If the specimen breaks in the weld metal, it shall be considered acceptable provided that the minimum tensile strength of the pipe material has been achieved.

If a specimen breaks outside the weld zone at a tensile strength not less than 95 % of that of the specified minimum tensile strength of the pipe material, that specimen shall be deemed to meet the test requirement.

Any specimen that breaks outside the weld zone at a tensile strength less than 95 % of that of the specified minimum tensile strength of the pipe material shall be rejected and an equal number of additional specimens shall be cut from the same test joint and subjected to the tensile test.

NOTE If any of the additional specimens break outside the weld zone at a tensile strength below the minimum stated above, the pipe material should be considered to be suspect and its physical properties should be investigated before any additional joints are made.

8.5.2.2.2 *Method*

The test specimens shall be in accordance with Figure 3. Machine the weld reinforcement and penetration bead flush with the pipe surface. Prepare the specimens by machine cutting.

The sides of the specimens shall be smooth and parallel and, where practicable, machining or grinding marks shall be parallel to the direction of tension.

Break the specimens under tensile load and calculate the tensile strength by dividing the maximum load at failure by the least cross-sectional area of the specimen as measured before the load was applied. Record also the temperature of testing.

8.5.2.3 *Macro-examination*

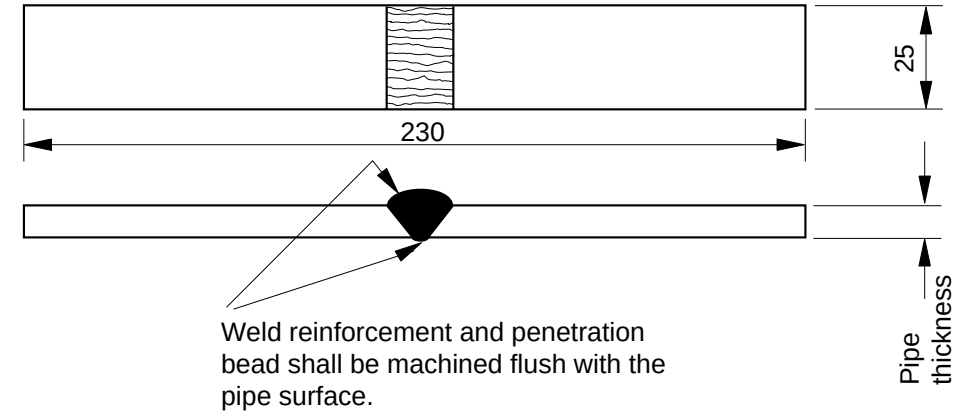
8.5.2.3.1 *Requirements*

When tested in accordance with **8.5.2.3.2**, the specimens shall be free from cracks and lack of fusion. Any other defects shall be within the limits specified in **12.1**.

8.5.2.3.2 *Method*

Cut transverse sections, suitable for examination of the weld and adjacent parent metal as close as possible to the locations shown in Figure 2 but at positions reported to be free from defects after non-destructive testing in accordance with **8.5.1**.

Prepare and etch the specimens as described in BS 709. Examine the polished and etched surfaces using a hand lens of ×5 magnification.



All dimensions are in millimetres

Figure 3 — Tensile test specimen

8.5.2.4 *Hardness survey*

Where specified by the employer, hardness measurements shall be carried out on the macro specimens in the weld metal and the HAZ using a method and meeting requirements as specified by the employer.

NOTE Particular consideration of the need for hardness control will arise for sour service operations and when cathodic protection is applied.

8.5.2.5 *Micro-examination*

8.5.2.5.1 *Requirements*

When specified by the employer the proportion of ferrite in the microstructure shall be determined and shall lie within the range specified by the employer. In addition, the presence of any third phase shall be reported to the employer.

8.5.2.5.2 *Method*

Determine the volume fraction of ferrite in accordance with annex B or an alternative method approved by the employer.

8.5.2.6 *Charpy V-notch impact test*

8.5.2.6.1 *Requirements*

When tested as described in **8.5.2.6.2**, the value of impact energy for each set of three specimens shall be not less than 50 J average and 40 J minimum individual value, when tested at the minimum design temperature or a lower temperature to be specified by the employer. The impact energy values for sub-size specimens shall be reduced pro rata with their dimensions. These Charpy requirements are applicable at minimum design temperatures down to −60 °C and for wall thicknesses up to and including 50 mm. The position of the test specimens shall be as shown in Figure 4.

If the impact energy measured is less than the specified average and minimum individual values, the material shall be considered to have failed the test.

NOTE However, for such material, CTOD testing may be considered for welding procedure approval with the approval of the employer.

Where the minimum design temperature is less than −60 °C or the pipe thickness is greater than 50 mm, CTOD testing may be considered for welding procedure approval with the approval of the employer.

8.5.2.6.2 *Method*

From each of the locations shown in Figure 2, machine, transverse to the weld, two sets of three Charpy V-notch specimens. Take the weld metal specimens such that the notch is in the vertical centre of the weld metal and the fusion line specimens such that the fusion line passes through the centre of the vertical notch. For pipes of thickness up to and including 20 mm, take the specimens from a location within 2 mm of the root surface of the weld. For pipe of thickness over 20 mm, take two additional sets of specimens in the cap, one notched on the weld centre line and one notched on the weld fusion line, located as close as practicable to the 12 o'clock position as shown in Figure 4. For pipe thicknesses 35 mm and over, take two additional sets of specimens from the mid-thickness position; one notched on the weld centre line and one notched on the fusion line at a location as close as possible to the 12 o'clock position. The circumferential position shall be subject to approval by the employer.

The exact size of the specimens depends on the wall thickness, but select the largest possible size. Machine, notch and test the specimens as described in BS EN 10045-1. Where the wall thickness and pipe diameter do not permit a specimen larger or equal to 10 × 5 mm to be taken then testing is not required.

8.5.2.7 *Corrosion test*

When required by the employer, the specimens shall be corrosion tested in accordance with annex C.

If the specimen has gained weight or lost ≤5 g/m^2 and if no pits are visible on the test face(s), it shall be considered to have passed the test. If pits are visible on the test face(s), the specimen shall be considered to have failed the test.

If the weight loss is >5 g/m^2, the specimen shall be considered to have failed the test, unless pitting is positively identified only on areas outside of the test face.

If one or both specimens show pitting on any face other than the test face, a further test (comprising 2 specimens) shall be carried out. For acceptance, all specimens tested shall meet the above criteria.

8.6 Testing of fillet welds for procedure qualification

8.6.1 ***Non-destructive testing***

All fillet welds shall be examined visually in accordance with BS EN 970 (see **11.3**) and shall undergo dye penetrant examination in accordance with **11.6**.

The results from visual examination and non-destructive testing shall be assessed according to the appropriate acceptance criteria specified in **12.1**.

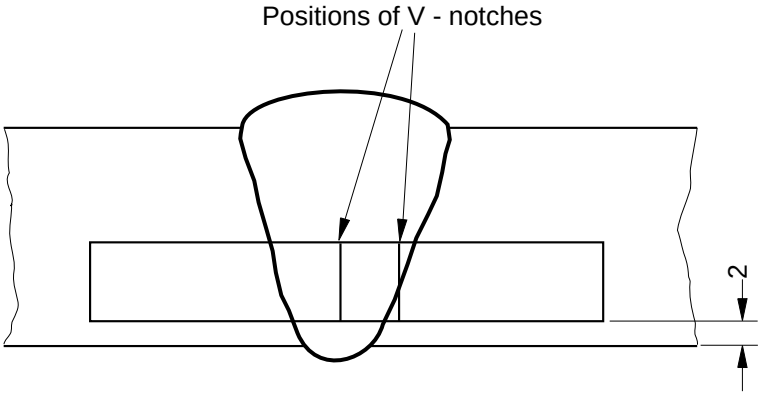
8.6.2 ***Macro-examination***

8.6.2.1 *Requirements*

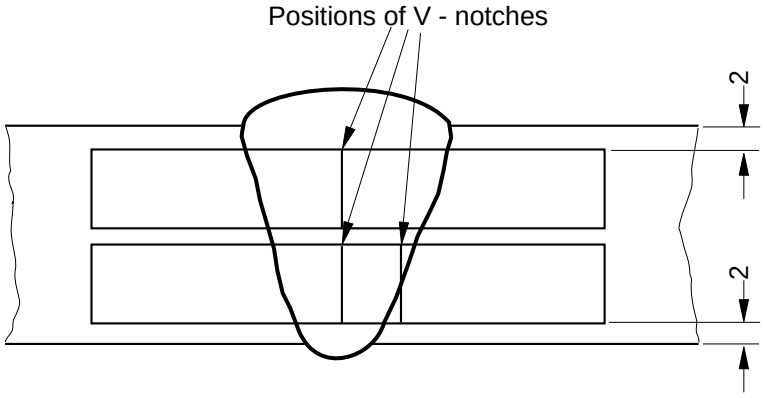
When tested in accordance with **8.6.2.2**, the profile, dimensions and number of runs of the fillet weld shall be as specified in the preliminary welding procedure. The specimens shall be free from cracks, lack of fusion and lack of penetration and the total area of any cavities or inclusions shall not exceed 5 % of the fillet weld cross-sectional area.

8.6.2.2 *Method*

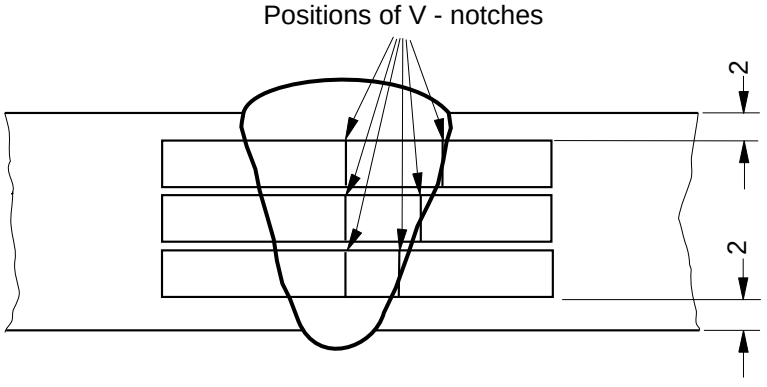
Prepare and etch the specimens in accordance with BS 709. Examine the polished and etched surfaces using a hand lens of ×5 magnification.



a) Up to and including 20 mm thick



b) Over 20 mm thick



c) 35 mm thick and over

Figure 4 — Charpy V-notch impact test specimens for full penetration welds (including full penetration repair welds)

8.6.3 ***Hardness survey***

Where specified by the employer, hardness measurements shall be carried out on the macro specimens in the weld metal and the HAZ using a method and meeting requirements as specified by the employer.

NOTE Particular consideration of the need for hardness control will arise for sour service operations and when cathodic protection is applied.

8.7 Testing of repair welds for procedure qualification

8.7.1 ***Non-destructive testing***

All test welds shall be subjected to non-destructive testing in accordance with **8.5.1**.

8.7.2 ***Destructive testing***

8.7.2.1 *Test specimens*

Test specimens shall be cut from the repair test weld as shown in Figure 1. The minimum number of specimens and the tests to which they shall be subjected shall be in accordance with Table 3.

8.7.2.2 *Transverse tensile test*

The requirements and method of testing shall be as specified in **8.5.2.2** except that, when the original WPS is being used for the repair, only full penetration repair and re-repair procedures need be tested.

8.7.2.3 *Macro-examination*

The requirements and method of testing shall be as specified in **8.5.2.3**.

8.7.2.4 *Hardness survey*

Where specified by the employer, hardness measurements shall be carried out on the macro specimens in the weld metal and the HAZ using a method and meeting requirements as specified by the employer.

NOTE Particular consideration of the need for hardness control will arise for sour service operations.

8.7.2.5 *Micro-examination*

The requirements and method of testing shall be as specified in **8.5.2.3**.

8.7.2.6 *Charpy V-notch impact test*

8.7.2.6.1 *Requirements*

The requirements shall be as specified in **8.5.2.6.1**. The position of the test specimens shall be as shown in Figure 5 except when the original qualified WPS is used for repair, Charpy testing is not required.

8.7.2.6.2 *Method*

Test full penetration repairs in accordance with **8.5.2.6.2**.

For partial penetration repairs and multi-pass back-weld repairs take two sets of three fusion line Charpy impact test specimens (pipe side and original weld side notched as shown in Figure 5) in addition to one set of three specimens at the repair weld centreline. For wall thickness over 20 mm the repair weld fusion line shall pass through the centre of the notch in the test specimens (see Figure 5a). For pipe of thickness up to and including 20 mm, the repair weld fusion line shall pass through the notch in the fusion line test specimens at a depth of half the penetration of the repair weld (see Figure 5b).

8.7.2.7 *Corrosion test*

When required by the employer, corrosion testing in accordance with annex C shall be carried out. For full penetration, repair or internal repair welds, one specimen shall be taken from the repair weld's internal surface and the other so as to contain 5 mm of repair weld internal surface and 20mm of the adjacent original weld root from the root pass of the original weld as shown in Figure 6.

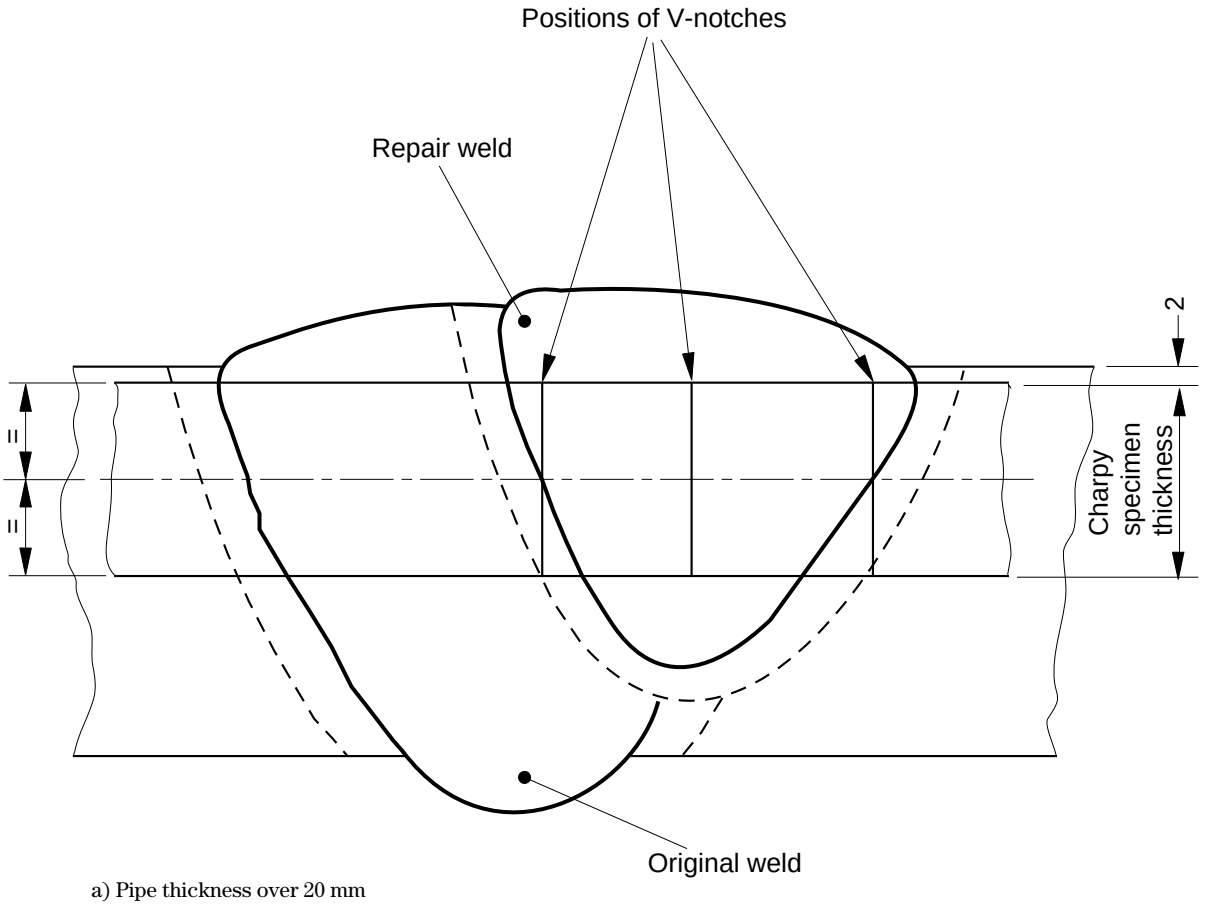
If the specimen has gained weight or lost ≤ 5 g/m^2 and if no pits are visible on the test face(s), it shall be considered to have passed the test. If pits are visible on the test face(s), the specimen shall be considered to have failed the test.

Table 3 — Number of specimens for procedure qualification tests on repair welds

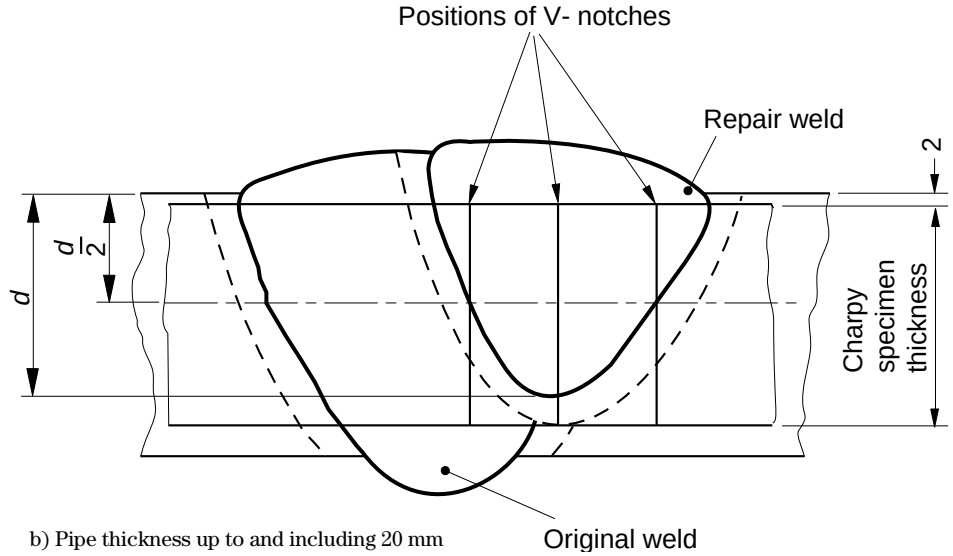
	Full penetration	Other external repairs		Internal (back-weld) repairs	
		Multi-pass	Single pass	Multi-pass	Single pass
Transverse tensile	1	1[b]	—	1[b]	—
Macro	1	1	1	1	1
Hardness[a]	1	1	1	1	1
Micro[a]	1	1	1	1	1
Weld metal Charpy	1 set	1 set[b]	—	1 set[b]	—
Fusion line Charpy	2 sets	2 sets[b]	—	2 sets[b]	—
Corrosion[a]	2	—	—	2	2

[a] When required by the employer.

[b] Not required when the original WPS is used for repair.



a) Pipe thickness over 20 mm



b) Pipe thickness up to and including 20 mm

All dimensions are in millimetres

Figure 5 — Positioning of Charpy V-notch impact specimens for procedure approval of partial penetration repair welds

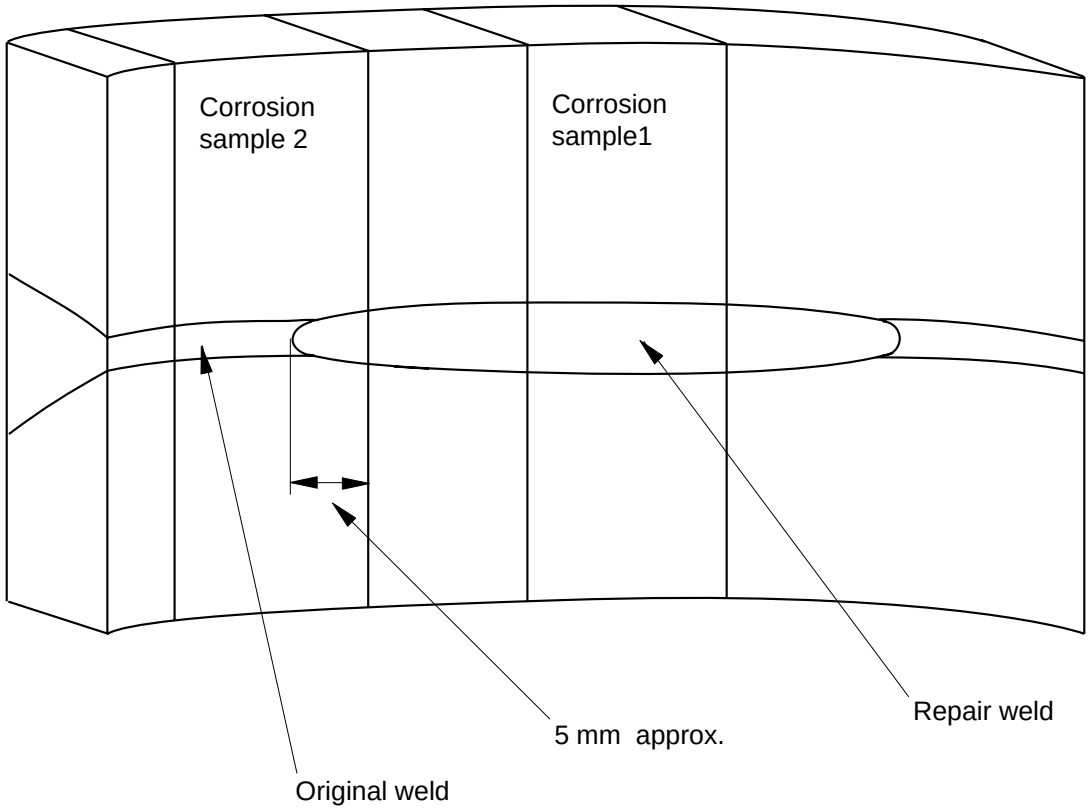


Figure 6 — Position of corrosion test specimen: full penetration and internal repair welds

If the weight loss is >5 g/m^2, the specimen shall be considered to have failed the test, unless pitting is positively identified only on areas outside of the test face.

If one or both specimens show pitting on any face other than the test face, a further test (comprising 2 specimens) shall be carried out. For acceptance all specimens tested shall meet the above criteria.

9 Testing, qualification and approval of welders

9.1 General

Each welder shall use a qualified procedure to make the welds or parts of welds he will be required to make on the pipelines. A welder who has satisfactorily completed a welding procedure qualification test shall automatically be qualified in that procedure.

Where more than one process or welder is employed in producing a complete welded joint, the successful testing of the completed weld shall qualify each welder for his respective portion. Each welder's portion shall be clearly identified. When a welder does not complete the whole joint, the root run shall include a stop/start position.

Each welder shall weld that portion of the pipe circumference which he will weld in construction in accordance with the qualified welding procedure.

A welder shall be given a single qualification for one or more of the following categories, a separate test being required for each category:

a) butt joint;

b) branch connections;

c) fillet welds for sleeves, sockets, slip-on flanges, other attachments and pipe supports.

The validity of the welder's qualification begins from the date when all the required tests are satisfactorily completed. This date may be different to the date of issue marked on the certificate.

A welder's qualification shall remain valid providing that the relevant certificate is signed at six month intervals by the employer/co-ordinator and that all the following conditions are fulfilled.

d) The welder is engaged with reasonable continuity on welding work within the current range of qualification. An interruption for a period no longer than six months is permitted.

e) There is no specific reason to question the welder's skill and knowledge.

If any of these conditions are not fulfilled, the qualification shall be considered to be invalid.

9.2 Butt joints

9.2.1 *Roll welding*

The test joint shall be made between two lengths of pipe rolled about the horizontal axis. The welder shall deposit metal at or near the position specified in the welding procedure until he has completed 200 mm or slightly less than 25% of the joint, whichever is the greater.

9.2.2 *Positional welding*

The pipe containing the test joint shall be fixed as follows.

a) *Within 20° of horizontal.* The pipe containing the test joint shall be fixed horizontally.

b) *Within 20° of vertical.* The pipe containing the test joint shall be fixed vertically.

c) *Between 20° to the vertical and 20° to the horizontal.* The pipe containing the test joint shall be fixed at 45° to the vertical.

9.3 Branch connections

Unless more than one process is used, each welder shall make all the runs on the full circumference of a branch.

A test weld shall be made with the branch and main pipe axes both horizontal, or at the actual angle of production welding.

9.4 Fillet welds for sleeves, sockets, slip-on flanges or other attachments

9.4.1 *General*

A successful single qualification test on either one of the items listed in a) or b) shall qualify a welder for all the attachments given in a) within the limits specified in **9.5**.

a) Sleeve, socket, slip-on flange or other type of attachment.

b) With prior approval of the employer, a simulation of the joint using flat plate material.

9.4.2 *Fillet welds in the flat or horizontal-vertical positions*

The test weld shall be made between a sleeve, socket, flange or other attachment and a length of pipe rotated about the horizontal axis or on a simulated joint in plate (see **9.4.1**). The welder shall deposit metal at or near top dead centre until he has completed 200 mm or slightly less than 25 % of the joint, whichever is the greater.

NOTE After leaving a short distance unwelded, another welder may weld a similar joint portion, and so on, thus making it possible to test up to four welders on one joint.

9.4.3 *Fillet welds in all positions*

The test weld shall be made between a sleeve, socket, flange or other attachment and a length of pipe fixed with the axis horizontal. When a simulated joint is used, the plates shall be positioned to cover for all the welding positions for which approval is required.

9.5 Changes affecting qualification and approval (essential variables)

A welder who has successfully completed a qualification test as detailed in **9.1** to **9.4** shall be qualified for the type and position of weld concerned within the limits of the following items. If any of the following occur, the welder using the new procedure shall be re-qualified.

a) A change from one welding process to another welding process or combination of welding processes.

b) A change in direction of welding from vertical-up to vertical-down or vice versa.

c) For butt joints and branch connections, a change in pipe diameter or thickness outside the ranges given in Table 4 (for branches, the diameter of the branch is the applicable dimension).

d) For a branch connection, a change in branch orientation exceeding 20° from that approved, except that approval on a connection with the branch and main pipe axes both horizontal gives approval for all welding positions.

e) A change in joint design, e.g. backing ring to no backing ring, or single U to single V preparation.

f) For manual metal-arc welding a change from one electrode covering type to another.

g) For continuous tubular electrodes: a change from metal cored to flux-cored, or vice versa; a change from one flux type to another; a change from gas shielded to non-shielded or vice versa.

h) Any change in the nominal composition of the shielding gas.

i) Any other change in the welding procedure or equipment which, in the opinion of the employer, will make production of a sound weld more difficult for the welder.

Table 4 — Diameter and thickness ranges for butt joints and branch connections

Diameter of test pipe D	Diameter range approved	Throat thickness of test pipe t	Thickness range approved
$D \leq 150$ mm	$0.5D$ to $2D$	$t \leq 12$ mm	$\leq 2t$
$D > 150$ mm	$\geq 0.5D$	$t > 12$ mm	≥ 5 mm

NOTE The value of D is the nominal pipe size, and the approved range should also be quoted in nominal pipe sizes, e.g. a test on D = 114.3 mm qualifies from D = 60.3 to D = 219.1 mm.

9.6 Non-destructive testing

The test weld shall present a neat workmanlike appearance and shall be assessed by visual examination according to the appropriate acceptance criteria in **12.1**.

After acceptance by visual examination (see **11.3**), non-destructive testing shall be carried out on each of the test welds using X-radiography (see **11.4**) or, with the prior approval of the employer, an alternative method(s).

The resultant film or other results shall be assessed in accordance with **12.1**.

9.7 Destructive testing

9.7.1 *General*

Butt joints shall only be subjected to destructive testing if the results of non-destructive testing are to be confirmed. Fillet welds shall always be subjected to destructive testing.

9.7.2 *Butt joints*

When required, the testing of butt joints for welder qualification shall conform to the requirements for macro-examination as specified for procedure approval tests in **8.5.2.3**.

9.7.3 *Fillet welds*

The testing of fillet welds for welder qualification shall comply with the requirements for procedure approval tests as specified in **8.6**, except that no hardness survey is required.

9.8 Retests

When failure of a welder to pass the test was because of conditions beyond his control, such a welder shall, with the approval of the employer, be given a second opportunity to gain approval. No further retests shall be given until the contractor has submitted proof of subsequent training of the welder acceptable to the employer.

Should one of the destructive test specimens fail to meet the relevant test requirements, two additional specimens shall be taken from the positions immediately adjacent to and on either side of the failed specimen. The welder is not regarded as qualified if either additional specimen also fails to satisfy the test requirements.

9.9 Records

The details of each welder's qualification test and test results shall be recorded on a welder qualification certificate. All documentation relating to welder qualification tests shall be submitted to the employer for approval prior to the welder commencing production work.

9.10 Mechanized welding

For mechanized welding, each welder shall be qualified for a particular part or parts of the operation of making a welded joint.

Under no circumstances shall a welder be employed on operations other than those for which he has been tested, qualified and approved.

The inspection and testing of welds for qualification purposes, and records, shall be in accordance with **9.6**, **9.7**, **9.8** and **9.9**.

10 Production welding

10.1 Proximity of welds

Adjacent welds shall have a toe-to-toe distance not less than four times the wall thickness.

NOTE Welds should be separated by the maximum possible distance.

10.2 Pipe end preparation

Bevelling shall be done by machining, or by machine plasma cutting followed by filing or grinding.

If burns, small score marks, indentations or other minor imperfections occur within the joint preparation area, the pipe shall be re-prepared unless blending out by grinding is approved by the employer.

Damage to pipe by bevelling machines shall be repaired in accordance with the pipe material specification.

On pipe which is cut back, the end zone shall be examined visually and by ultrasonic examination where appropriate to verify compliance with the requirements of the relevant pipe material specification.

When a weld is intended to be examined by ultrasonic testing, datum points shall be marked on both sides of the joint (before welding commences) at a known distance from the root face of that component. The method of marking shall be subject to approval by the employer.

NOTE The datum points enable the ultrasonic operator to locate reflectors in relation to the weld preparation. In the absence of a clear datum, root profile reflections could be incorrectly identified as volumetric defects.

10.3 Fusion faces

The fusion faces and the adjacent material shall be free from fins, planar flaws not conforming to **12.1**, tears, moisture, scale, rust, paint, grease or other foreign matter immediately prior to welding. Cleaning to base metal shall extend for at least 25 mm from the edge of the fusion faces on both internal and external faces of the parts to be welded.

10.4 Alignment

The alignment of abutting pipe ends shall be such as to minimize the internal offset between surfaces. Any offset greater than 1.5 mm, provided it is caused by dimensional variations within specified tolerances, shall be equally distributed around the circumference of the pipe or fittings. Any misalignment shall be reduced to a minimum, by rotation of the pipes to obtain best fit or by other methods approved by the employer.

When a pipe with one longitudinal seam is used, this seam shall be within the top half of the pipe circumference and the longitudinal seams of adjacent full pipe lengths shall be offset by an angle of approximately 90° or by a circumferential distance of approximately 250 mm, whichever is smaller.

For pipes of different nominal thickness and the same outside diameter, alignment with a taper not steeper than 1 in 4 shall be achieved as specified by insertion of a transition piece or provided that the design strength of the thicker pipe is equal to or greater than that of the thinner pipe, the smaller bore shall be machined, ground or filed.

NOTE It should be recognized that the ends of pipes and fittings will be supplied to standard tolerances and may not match, especially if placed together at random. Additional workmanship may, therefore, be required to ensure that the required alignment is achieved.

10.5 Line-up clamps and pipe supports

10.5.1 *Use of line-up clamps*

Whenever practicable, internal line-up clamps shall be used to hold pipes firmly in position. Other alignment methods shall be subject to approval by the employer.

Internal line-up clamps shall not be released before the completion of the root run. The pipe shall remain adequately supported after release of the clamp. On no account shall straps, brackets, cleats or similar plate sections be attached to the pipe by welding for the purposes of alignment.

NOTE It is recommended that power-operated internal clamps be used to reduce ovality and improve line-up.

External line-up clamps shall not be released until the completed part of the root run covers a minimum of 50% of the circumference of the joint, uniformly spaced, the pipe remaining adequately supported on each side of the joint.

The stage at which line-up clamps are released shall be stated in the WPS and subject to the approval of the employer.

10.5.2 *Removal of pipe supports*

For landlines, the stage at which the pipe is lowered on to skids, or at which supports are removed in the case of fittings, shall be stated in the WPS and subject to the approval of the employer.

10.6 Tack welds

Root tack welds are not permitted. Where other types of tack welds are required, these shall be subject to approval by the employer.

10.7 Working clearance

The working clearance around the pipe at the weld shall be sufficient to provide adequate access for welding and inspection of the joint.

When the pipe is welded in a trench, the bell hole shall be of sufficient size to provide the welder or welders with ready access to the joint.

10.8 Stray arcs

Arcs shall be struck only on fusion faces and contact of the electrode or of the non-insulated parts of the electrode holder, with the outer surfaces of the pipe shall be avoided.

The pipe end shall be cut back to remove places where stray arcs have occurred, unless repair is approved by the employer.

Where permission to repair stray arcs has been given by the employer, the procedure shall include, but not necessarily be limited to, the mechanical removal of the defective material, blending of the excavation, checking by dye penetrant inspection and confirmation that the thickness of the pipe or fitting is within permitted tolerances.

With the approval of the employer, where the resulting thickness is below tolerance, repairs may be carried out using an approved welding procedure and may be subjected to further non-destructive testing.

10.9 Weather conditions

Welding shall not be undertaken when, in the opinion of the employer, the quality of the completed weld would be impaired by airborne moisture, blowing sands or high winds.

NOTE Where adequate protection from the weather can be provided, welding may be continued.

10.10 Preheating

NOTE Preheat is not normally required for duplex stainless steels but the pipe temperature may need to be raised to prevent condensation on the fusion faces.

10.11 Branches

10.11.1 *Angle of branch*

Where a sloping branch has to be connected directly to the main pipe, the angle between the centreline of the main and that of the branch pipe shall be not less than 60°. In cases where the angle between the main and the branch is unavoidably less than 60°, special precautions taken locally at the crotch to ensure a sound weld shall be subject to approval by the employer.

NOTE In view of the additional difficulty involved in making a satisfactory joint at the intersection of two pipes not at right angles, for branch pipes sloping away from a main pipe, consideration should be given to using a right angle branch and a bend to give the required slope. All branches should preferably be made with specialized fittings, e.g. forged or pressed tees, forged set-in or set-on components.

10.11.2 *Spacing of branches*

The spacing of branches on the main pipe and the lengths of flanged branches shall be such that there is adequate access for satisfactory welding.

10.11.3 *Joint preparation*

Branch connections and branch openings in the main pipe shall be cut by machining or by machine plasma cutting. The cut edges shall then be dressed by filing or grinding to the dimensions given in the approved welding procedure (see also **10.2**).

The ultrasonic examination of pipe material around planned cut-outs for nozzles shall be in accordance with the requirements of the pipe material specification. A written procedure shall be submitted to the employer for approval. The zone to be examined shall be at least 100 mm wide (see also **12.1.2**).

10.11.4 *Welding*

10.11.4.1 *Gap*

The gap shall be maintained during the deposition of the first run. Tack welds shall be used only in accordance with the requirements of **10.6**.

10.11.4.2 *Internal welds*

Internal welding shall only be carried out as specified in the approved welding procedure [see Table 1, item g)].

10.11.5 *Branch reinforcement (compensation)*

When the reinforcement plate is cut to shape, the cut edges shall be dressed by filing, grinding or machining.

The reinforcement shall be securely held in position by tack welds which shall be of sound quality (see **10.6**).

All welds shall be made in accordance with the appropriate qualified welding procedure.

10.12 Inter-run cleaning

Surface slag likely to produce unacceptable weld flaws shall be removed, either by hand or power tools, before a further run is applied. Carbon steel tools shall not be used.

Visible defects such as cracks, cavities and other deposition faults shall be removed, and particular attention paid to the cleanliness of the junctions between the weld metal and the fusion faces, before deposition of further weld metal.

Cluster or surface porosity, stops and starts, and high points shall be removed by grinding.

10.13 Partially completed joints

Whenever possible, joints shall not be left partially completed. Where production conditions are such that joints have to be left partially completed, the minimum number of runs deposited before cessation of backing gas supply shall be qualified in the approved welding procedure.

11 Inspection and testing of welds

11.1 General

The method or combination of methods and frequency of visual inspection and non-destructive testing shall be as specified by the employer.

Prior to the start of welding, all NDT procedures to be used shall be submitted to the employer for approval.

If the employer requires completed welds to be ground, this shall be stated in the enquiry and order. When a weld is to be ground, overheating due to the grinding action shall be avoided.

11.2 Personnel qualification

All inspection personnel shall have been approved by the employer.

11.3 Visual inspection

All welds shall be visually examined in accordance with BS EN 970 on the outside surface and, where practicable, in the bore. Visually detectable flaws shall be assessed in accordance with **12.1**.

11.4 Radiographic testing

11.4.1 *General*

The radiographic testing of fusion welded circumferential butt joints in duplex stainless steel pipes shall be carried out in accordance with BS EN 1435 using a class B technique or better as approved by the employer. The test arrangement(s) shall conform with one or more of the following clauses of BS EN 1435:1997, **6.1.4**, **6.1.5**, **6.1.6** and **6.1.8**.

11.4.2 *Approved radiographic procedures*

The procedure details shall include the following, as appropriate:

a) technique;

b) type of equipment, exposure container (in accordance with BS 5650) and kV rating;

c) type and class of film;

d) intensifying screens;

e) cassette (film), shielding and beam collimation;

f) source dimensions or focal spot size (in mm);

g) geometric relationship (defined by sketch);

h) length of weld covered on each radiograph and number of radiographs to be taken;

i) tube voltage, type and strength of source;

j) material thickness range;

k) surface condition and profile;

l) type, size and position of image quality indicator (IQI);

m) IQI value required;

n) film density;

o) processing;

p) exposure time(s);

q) limitations of the procedure.

The radiographs used to approve the procedure shall show the image quality indicators placed on the source side and the film side of the area being examined. When using a wire type IQI, the wires shall be directed perpendicular to the weld and its location shall ensure that at least 10 mm of the wire length will show in a section of uniform optical density. The contractual IQI quality level shall be achieved using the source side IQI and (for correlation with production welds) the corresponding quality level on the film side shall be recorded.

11.4.3 *Film storage*

All unexposed films shall be stored in a clean, dry place where the surrounding conditions will not detrimentally affect the emulsion.

11.5 Ultrasonic testing

Specific procedures, acceptance criteria, report format, method of data storage and presentation shall be agreed in order to establish suitable performance for the intended application. The proposed technique shall be demonstrated and validated before being applied to production welds.

NOTE 1 In common with fully-austenitic materials, there are practical difficulties in applying ultrasonic testing to duplex stainless steels, and employers should be aware of the limitations, notably the restriction to half-skip examination and the uncertainties in beam path through weld metal.

NOTE 2 The use of realistic flaw reference samples based on the actual joint geometry and welding procedure may be required for this purpose.

11.6 Dye penetrant examination

The extent of the testing shall be to cover the weld, HAZ and weld toe regions. The dye penetrant testing shall be in accordance with BS EN 571-1.

12 Acceptance and rectification of welds

12.1 Non-destructive testing acceptance criteria

12.1.1 *General*

The acceptance criteria for non-destructive testing shall be in accordance with **12.1.2** or, if specified by the employer, in accordance with **12.1.3**.

12.1.2 *Acceptance criteria based on quality control*

In areas of a weld preparation such as pipe ends, fusion faces and branches (see **10.2**, **10.3** and **10.11.3**) no planar flaws shall exceed the dimensions specified in the pipe material specification.

Acceptance criteria for welds shall be in accordance with Table 5.

Any accumulation of flaws, except porosity, affecting a total length of weld of 100 mm or more in any continuous weld length of 300 mm or a total length of 15 % or more of the weld length, whichever is the greater, shall not be accepted.

The acceptance criteria specified in Table 5 apply to non-destructive testing by visual or radiographic examination. As no “equivalent” ultrasonic testing table has been derived, acceptance criteria for ultrasonic examination shall be subject to approval by the employer before welding begins.

NOTE The dimensional limitations of flaws subject to rejection specified in this sub-clause are intended to ensure good quality welded joints. Service conditions may exist, however, that require a higher standard and when such conditions apply the higher standard required should be clearly stated.

12.1.3 *Acceptance criteria based on engineering critical assessment*

When the employer specifies that engineering critical assessment (ECA) is to be used for establishing acceptance criteria, it shall be applied in accordance with PD 6493.

12.2 Rectification of welds

12.2.1 *Removal of flaws*

When a weld fails to conform wholly or in part with **12.1**, either the weld shall be repaired locally or the weld zone shall be entirely removed. No weld shall be repaired without the approval of the employer.

The excavated portion of the weld shall be sufficiently deep and long to remove the flaw. Flaws shall be removed by chipping, grinding, or machining or other methods approved by the employer. Entire welds shall be removed by plasma cutting or machining. Weld repairs shall not begin before sufficient non-destructive testing and inspection has been completed to ensure complete removal of the flaw.

Repairs shall be limited to 30 % of the weld length for a partial penetration repair, or 20 % of the weld length for a full penetration repair. If longer repair length limits are proposed they shall be subject to approval by the employer.

NOTE Stresses imposed by construction techniques existing at the time of making a repair, e.g. at a laybarge repair station, may be such that to remove 20 % of the weld length would be unsafe.

12.2.2 *Preparation for re-welding*

At the ends and sides of the excavation there shall be a gradual taper from the base of the excavation to the surface of the weld metal. The width and profile of the excavation shall be such as will give adequate access for re-welding.

If the thickness of the remaining metal under a partial penetration repair is less than 6 mm, the bore purge required for the initial weld shall be reinstated for the duration of the repair. A qualified full penetration welding procedure shall be used for the repair welding.

12.2.3 *Qualifications*

All repair welding procedures shall be qualified and submitted to the employer for approval. A full penetration repair test shall approve all repair procedures except for back-weld repairs.

12.2.4 *Re-welding*

A repaired weld shall be subject to at least the same testing and inspection requirements as the original weld. Repairs shall not be attempted more than once unless approved by the employer.

Back-weld repairs shall only be undertaken if approved by the employer.

Repairs shall only be implemented under constant supervision. If repairs are not effected successfully, the weld shall be cut out. Re-repairs of root defects are not permitted.

Full records of all repairs shall be maintained

Table 5 — Acceptance criteria for welds

Flaw type[a]	Acceptance criteria
a) External profile	Excess weld metal (reinforcement) shall be uniform and shall merge smoothly with the parent metal and shall extend beyond the original joint preparation by not more than 3 mm on each side. In no area shall the weld face be lower than the adjacent pipe surface. Fillet welds shall be not less than the specified dimensions, regular in form, and without undercut as given in h).
b) Internal profile	The root bead or any concavity shall merge smoothly into the adjacent surfaces.
c) Root penetration	Shall not exceed 3 mm. If service conditions necessitate a more stringent limit, this shall be specified by the employer.
d) Root concavity	Length shall not exceed 25 % of total length of weld. Depth shall not exceed 10 % of pipe thickness, or 1.5 mm, whichever is the smaller, but at no point shall the weld, including cap reinforcement, be thinner than the pipe thickness.
e) Root undercut[b]	Length shall not exceed 25 mm in any continuous weld length of 300 mm, or 1/12 of the total length of the weld where this is less than 300 mm. Depth shall not exceed 10 % of pipe thickness, or 1.5 mm, whichever is the smaller. For branch welds this flaw is not permitted.
f) Incomplete root penetration[b] (single side welds only) Lack of root fusion[b] (single side welds only)	Length shall not exceed 25 mm in any continuous weld length of 300 mm, or 1/12 of the total length of the weld where this is less than 300 mm. For branch welds this flaw is not permitted.
g) Cracks	Not permitted.
h) Cap undercut	The toes of welds shall blend smoothly and gradually into the parent metal. Length not to exceed 50 mm in any continuous weld length of 300 mm, or 1/6 of the total length of the weld where this is less than 300 mm. Depth not to exceed 10 % of pipe thickness or 1.5 mm, whichever is the smaller. For branch welds the length of weld affected not to exceed 25 mm in any continuous weld length of 300 mm, or 1/12 of the total length of the weld where this is less than 300 mm.
i) Shrinkage cavity Lack of inter-run fusion Lack of sidewall fusion Elongated inclusions Incomplete root penetration (double sided welds only[c])	Length of weld affected shall not exceed 50 mm in any continuous weld length of 300 mm, or 1/6 of the total length of the weld where this is less than 300 mm. Width of elongated inclusions shall not exceed 1.5 mm. For branch welds the length of weld affected shall not exceed 25 mm in any continuous weld length of 300 mm, or 1/12 of the total length of the weld where this is less than 300 mm.
j) Porosity	Shall not exceed a total area, when projected radially through the weld, of 1 % of projected weld area in the radiograph (consisting of the length of the weld affected by the porosity, with a minimum length of 150 mm, multiplied by the maximum width of the weld). An isolated pore greater than 25 % of the pipe thickness or 3 mm, whichever is the smaller, in any direction shall be considered unacceptable.
k) Isolated inclusions (tungsten or non-elongated slag)	Width of inclusion shall not exceed 3 mm or half pipe thickness, whichever is the smaller. Total length of inclusions not to exceed 12 mm in any continuous weld length of 300 mm, and not more than four inclusions of maximum width in this 300 mm length. Adjacent inclusions shall be separated by a minimum distance of 50 mm.
l) Copper inclusions	Not permitted.
m) Burn-through	Not permitted.
m) Wormhole	Shall not exceed 6 mm in length or 1.5 mm in diameter for thicknesses not exceeding 25 mm, or a total length of 25 % of the thickness or 12 mm, whichever is the smaller, or 3 mm in diameter for thicknesses over 25 mm.

[a] For definitions see BS 499-1.
[b] Environmental conditions where crevice corrosion is a risk may require more stringent acceptance criteria.
[c] Also known as “Lack of cross penetration”.

Annex A (informative)
Example of a welding procedure specification form

Welding Procedure Specification — Page 1 of 2			
Procedure No.:		Revision No.:	
Base material			
Specified Standard:	UNS Number:	Calculated PRE_N:	
Chromium: %	Molybdenum: %	Tungsten: %	Nitrogen: %
Diameter and thickness			
Nominal Outside Diameter: mm		Nominal wall thickness: mm	
Joint configuration			
Sketch of configuration	Pipe end preparation	Number and sequence of runs	
	Bevel angle: ° ± °		
	Root face: mm ± mm		
	Root gap: mm ± mm		
	Backing ring:		
Welding position			
Angle of pipe axis to horizontal:			
Direction of welding			
Vertical up, vertical down or horizontal:			
Line-up clamp			
Internal, external or alternative:		Number of runs before removal:	
Welding process			
Runs	Process	Manual, semiautomatic or mechanized	Pulsed or non-pulsed
Preheat and interpass temperature			
Preheat/minimum interpass temperature: °C		Maximum interpass temperature: °C	
Shielding gas			
Run number(s):	Nominal composition:	Flow rate:	
Backing gas			
Nominal composition:		Number of runs with backing purge:	
Maximum oxygen content (ppm):		Method of monitoring oxygen:	
Shielding flux			
Trade name:		Type:	
Lowering-off or barge move-up			
Number of runs before this activity commences:			

Example of a welding procedure specification form *(concluded)*

Welding Procedure Specification — Page 2 of 2							
Procedure No.:				Revision No.:			
Electrode or filler metal [State where a twin or multi-wire process is used, and give parameters separately for each wire]							
Run number(s)	Nominal diameter	Trade name		Classification		Drying/Pre-treatment	
Welding parameters							
Run number(s)	Welding process	Electrode extension or tungsten diameter	AC, DC+, DC−	Arc Voltage	Welding current	Travel speed	Calculated arc energy
Pulsed welding parameters							
Run number(s)	Peak current	Background current		Pulse frequency		Pulse (peak) duration	
Welding technique [mechanized]							
Run number(s)	Maximum weave amplitude	Weave frequency		Dwell time at bevel			

Annex B (normative)

Method for determining volume fraction of ferrite in duplex stainless steel weldments by systematic point count

B.1 Basis of method

This method is based on that found in ASTM E562 but with additional procedures to cater for the examination of duplex stainless steel weldments.

B.2 Sample preparation

B.2.1 Planar sections shall be taken through the weldment, transverse to the welding direction and perpendicular to the material surface. The location and number of sections shall be as specified by the employer. Each section shall sample the whole of the weldment and HAZ and an area of parent material on either side of the weld. Preparation of these specimens shall be in accordance with ASTM E3. The last grinding stage shall be with 600 grit, or finer, abrasive and the final polish shall be with 1mm, or finer, abrasive (e.g. diamond paste).

B.2.2 The specimen shall be etched electrolytically in 40 % KOH solution (i.e. 400 g KOH in 1000 ml of solution made with distilled water). Etching shall be carried out in a container which allows immersion of the specimen in the etch at a distance of ≤100 mm from the platinum cathode. Electrical contact between the specimen and power source may be made by means of a suitably shaped conducting probe.

NOTE Acceptable contrast is generally best obtained at an anode/cathode voltage of 7-8 V for 2-5 s, but trials may be necessary to determine the most appropriate conditions for a particular specimen. It may be noted that the contrast between the ferrite and austenite phases will probably vary through the weldment.

B.3 Area selection

Measurements shall be performed in three areas: the root pass of the weld and in both adjacent HAZs within 2 mm of the root surface and within 0.2 mm of the fusion boundary.

B.4 Equipment

B.4.1 An optical light microscope which projects an image of the magnified microstructure onto a viewing screen shall be used, with graduated x and y translation controls. The magnification shall be selected such that the austenite grains have an average dimension approximately one half of the grid point spacing. This should be judged visually in more than one field of view, before measurements are made.

NOTE For many weldment microstructures, particularly in re-heated areas, a magnification in the range ×500 to ×1000 is suitable, and is preferred.

B.4.2 The test grid shall be marked on a transparent sheet which shall be superimposed on the magnified image of the microstructure. The grid shall consist of a square array of equally spaced points, produced by the intersection of fine parallel lines (maximum width 0.3 mm), and shall have 16 or 25 points. The spacing of the points shall be 10 mm along both directions parallel to the edges of the square grid (see ASTM E562). At a magnification of ×1000, this corresponds to a point spacing on the actual microstructure of 10 μm.

B.5 Procedure

B.5.1 Superimpose the test grid on the magnified image of the microstructure in the chosen area of the weldment such that it is approximately parallel to the fusion boundary for HAZ measurements.

B.5.2 Count the number of points which lie within the ferrite phase; any points which cannot be assigned positively to either phase shall be counted as one half.

NOTE Ferrite is the phase which is stained dark by the etch, although its colour may vary significantly throughout the weldment. The austenite phase remains light coloured in all areas after etching.

B.5.3 The specimen shall then be moved in the x and/or y directions so that another field is chosen. A second point count shall be performed in the new field, provided that this field of view still falls within the specified region of the weldment. If the field of view falls outside the area of interest, the specimen shall be moved back, preferably without rotating, to an appropriate position within the specified area. Where possible, the specimen shall be moved without looking at the microstructure, in order to avoid bias in the choice of fields. Overlapping fields shall be avoided. This process shall be repeated until a minimum of 400 points have been assessed.

B.5.4 The volume fraction of ferrite, 95 % confidence interval (CI) and percentage relative accuracy (%RA) (formerly percent error) shall be calculated in accordance with ASTM E562.

B.5.5 Where the percentage relative accuracy exceeds 10 %, this shall be drawn to the attention of the employer.

B.6 Reporting

The following details shall be included in the point counting report:

a) the number of sections taken from the weld;
b) the locations of sections taken along the weld;
c) the polishing procedure and etching conditions;
d) the magnification used;
e) the number of points and shape of the grid;
f) whether the fields were chosen randomly or at regular intervals. If regular intervals were employed, the spacing used shall be reported;
g) the location of the areas in which measurements were made, preferably on a sketch or photograph and in words, specifying the region of the weld pass (i.e. weld metal or HAZ);
h) a list of the point fractions of ferrite in each field;
i) an estimate of the volume fraction of ferrite, calculated as the average of the point fractions;
j) the calculated value of the 95 % CI;
k) the calculated value of %RA.

Annex C (normative)

Method for pitting corrosion testing of duplex stainless steel weldments by the use of ferric chloride solution

C.1 Principle

The test involves total immersion of test specimens in an aqueous solution of ferric chloride at a constant temperature for a 24 h period. It assesses whether a specimen has passed or failed primarily on the basis of weight loss measurement. The temperature of exposure shall be specified by the employer.

C.2 Terminology

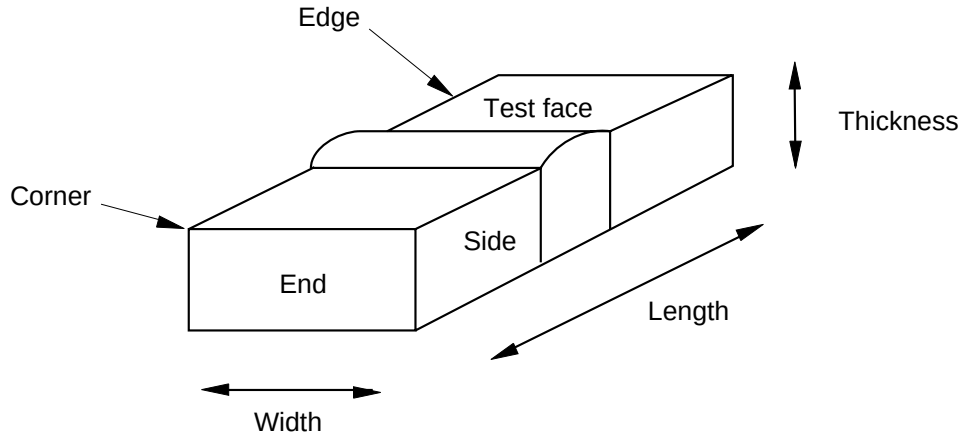
Figure C.1 specifies the nomenclature to be used to describe various aspects of the test piece.

a) The face including the area of weld to be tested shall be called the “test face”. If there are two “test faces” these shall be unambiguously named, e.g. the “root test face” and “cap test face”.
b) If there is only one “test face”, the face opposite shall be called the “reverse face”.

C.3 Test variables

Some variables are at the discretion of the employer and shall be specified before testing is initiated. These are:

a) test temperature;
b) which of the specimen faces are under test;
c) whether probing with a steel pin is required;
d) the number of re-tests allowed before the weld is considered to have failed;
e) any additional requirements, e.g. for welds made with 25% Cr consumables for the root pass and 22% Cr for the fill, whether pitting in the weld metal on the sides or reverse face of the specimen is acceptable.



NOTE The underside may be either a second test face or simply ground flat and referred to as the reverse face.

Figure C.1 — General layout of test specimen showing the test face uppermost

C.4 Sample preparation

C.4.1 The test face shall be "as prepared for service". No additional preparation shall be allowed.

C.4.2 Two samples from each weld shall be tested taken from positions specified by the employer.

C.4.3 An approximately cuboidal specimen (i.e. with six nominally rectangular faces) shall be used, with a test face size of 50 mm × 25 mm.

NOTE There is no specific limit on thickness but it is most convenient to test specimens of 5 mm to 10 mm thickness.

The weld direction shall be approximately parallel to the shorter edge of the test face, and the weld shall be positioned equidistant from the two ends of the specimen.

If the weld width on the test face exceeds one third of the specimen length, the length shall be increased to a value equal to at least three times the weld width. When comparisons are to be made between a series of specimens they shall all be of the same size and shall all meet the above length requirement.

Dimensions within ±10 % of those stated shall be considered acceptable. All corners of the test face shall be 90° ± 10°.

The specimen weight shall be sufficiently low to allow measurement to within ±1 mg. The maximum weight measurable on appropriate balances is commonly 200 g; therefore this is a sensible upper figure, but heavier specimens may be used if a suitable balance is available. Any samples showing discolouration as a result of cutting or machining shall be discarded. If the specimens are too heavy, they shall be machined on the reverse face to a suitable thickness.

C.4.4 The sides and ends of the specimen shall be ground to remove machining marks, using a suitable range of grit size, to produce a 600 grit finish in accordance with ASTM E3. If the reverse face requires machining to achieve the desired specimen thickness, it shall also be ground to a similar finish; otherwise the reverse face may be left as prepared for service, although it should be noted that attack may occur on this face also. All corners and edges shall be rounded off and have any burrs removed during the grinding process.

If pitting occurs on surfaces other than the test face attention shall be paid to improving the finish of these surfaces

C.4.5 Specimens shall not be marked with ink/paint.

NOTE Light stamping can be carried out for identification purposes in parent material outside of the test face and well away from the weld zone, i.e. on the ends or sides of the specimen. However, corrosion or pitting at these locations may render the test void. Alternatively, each specimen may be kept in a clearly labelled envelope prior to exposure and, after cleaning and drying, at the completion of the test.

C.5 Test solution

The test solution shall be made up from 100 g of reagent grade ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$) and 20 g of disodium ethylenediamine tetra-acetate di-hydrate ($Na_2EDTA \cdot 2H_2O$) per 900 ml of distilled water, or other water in accordance with type IV of ASTM D1193.

C.6 Equipment

C.6.1 The solution and specimen shall be contained in a tall-form glass beaker or a wide neck flask. A capacity of 1000 ml shall be sufficient for standard specimens, but larger capacity, e.g. 2000ml, may be necessary for non-standard specimens. Each specimen shall be placed in a separate container.

C.6.2 Each specimen shall sit at approximately 45° on a cradle designed to allow easy passage in and out of the container and ensure minimum contact with the specimen, so as to reduce the likelihood of crevice corrosion.

C.6.3 The containers shall be held within a constant temperature water bath, capable of maintaining a specified temperature to within ± 0.5 °C. The temperature of the bath shall be monitored throughout the test with a thermometer or a calibrated thermocouple.

C.6.4 Specimens shall be weighed using a balance capable of ±1 mg accuracy.

C.7 Procedure

C.7.1 Decontaminate the specimen with clean acetone, methanol, or petroleum ether and air dry, then weigh to the nearest 1 mg immediately prior to testing. If the specimen is to be stored, keep in a desiccator, and then clean it and weigh it prior to testing.

C.7.2 Place a minimum of 20 ml of test solution per 100 mm^2 of total specimen surface area in the test container.

C.7.3 Cover the container and solution with a watchglass and place in a water bath pre-heated to within ±0.5 °C of the specified test temperature.

C.7.4 Monitor the temperature of the solution. When it has reached ±0.5 °C of the specified test temperature, place the specimen on a cradle and immerse it in the test solution. Orient the specimen with its test face uppermost and at an angle of approximately 45° to the vertical. Maintain the test temperature within ±0.5°C of the required value throughout the exposure period.

C.7.5 Remove the specimen from the test solution after 24 h, rinse it and scrub it with a nylon bristle brush under running water and finally immerse it in acetone or methanol and dry it thoroughly.

NOTE The scrubbing process should remove any loose corrosion product and staining from the specimen surface.

C.7.6 When dry, re-weigh the specimen to ±1 mg or better.

C.7.7 After weighing, examine the specimen under a binocular microscope in order to identify the location of any pitting and/or general corrosion. If specified or if necessary, to clarify the location of any pitting, use a sharpened steel probe to open up covered pits.

C.8 Reporting

The following shall be included in the test report for each specimen tested.

a) A description of the weld condition, i.e. details of all post-weld treatments and surface preparation.

b) The specimen dimensions.

c) A sketch or description of the test specimen, prior to testing, showing the test face(s), the general shape of the weld and any notable features, in particular any which might be mistaken for pits after exposure.

d) The actual test temperature, including any variation noted during the test exposure.

e) The weight of the specimen immediately prior to testing.

f) The weight of the specimen after cleaning and drying at the completion of the test.

g) The weight change during testing.

h) The location of any pits discovered shall be recorded on a sketch of the specimen. If no pits are observed, this shall be stated. The use of probing shall be reported, with the observed results.

i) Whether the specimen has passed or failed the test.

Bibliography

Standards publications

BS 4515:1996, *Specification for welding of steel pipelines on land and offshore.*

BS EN 288-3:1992, *Specification and approval of welding procedures for metallic materials — Part 3: Welding procedure tests for the arc welding of steels.*

BS EN ISO 9000 (all parts), *Quality management and quality assurance standards.*

Other documents

[1] NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE). *Sulfide stress cracking resistant metallic materials for oilfield equipment.* NACE MR0175. Houston: NACE 1995.

[2] EUROPEAN FEDERATION OF CORROSION (EFC). *Corrosion resistant alloys for oil and gas production: Guidance on general requirements and test methods for H_2S service.* EFC publication no. 17, Institute of Materials, London 1996.

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL