

# Specification for welding of steel pipelines on land and offshore —

## Part 1: Carbon and carbon manganese 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
- BEAMA Ltd — Welding Manufacturers Association
- British Institute of Non-Destructive Testing
- Engineering Equipment and Materials Users Association
- HSE — Health and Safety Executive
- International Marine Contractors Association
- Offshore Contractors Association
- Pipeline Industries Guild
- UK Steel Association

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 24 November 2004

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First published as BS 4515  
October 1969  
First published as BS 4515-1  
July 2000  
Second edition November 2004

## Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
|          |      |          |
|          |      |          |
|          |      |          |
|          |      |          |
|          |      |          |

The following BSI references relate to the work on this British Standard:  
Committee reference: WEE/21/7  
Draft for comment 04/30088446 DC

ISBN 0 580 44622 0

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## Foreword

The revision of this British Standard has been prepared by Subcommittee WEE/21/7 and supersedes BS 4515-1:2000 which is withdrawn.

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

This standard should be used in conjunction with BS EN 288-9:1999.

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 288-9 (under which welding procedure approval is 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 is entrusted to appropriately qualified and competent people and that the Contractor will nominate a Welding Co-ordinator in accordance with BS EN 719.

*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.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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

## Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 56, an inside back cover and a back cover.

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## 1 Scope

This British Standard specifies requirements for the welding of carbon, carbon manganese and low alloy steel pipelines with specified minimum yield strengths not exceeding 555 N/mm<sup>2</sup> and designed in accordance with PD 8010-1 and PD 8010-2.

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

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

Information on hyperbaric welding is given in Annex A and on brazing and aluminothermic welding of anode bonding leads is given in Annex B.

Additional recommendations for the welding of corrosion resistant alloy clad and lined pipelines are given in Annex G.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 499-1:1991, *Welding terms and symbols — Part 1: Glossary for welding, brazing and thermal cutting*.

BS 4105, *Specification for liquid carbon dioxide, industrial*.

BS 6072:1981, *Method for magnetic particle flaw detection*.

BS 7910:1999, *Guide on methods for assessing the acceptability of flaws in metallic structures*.

BS EN 288-9:1999, *Specification and approval of welding procedures for metallic materials — Part 9: Welding procedure test for pipeline welding on land and offshore site butt welding of transmission pipelines*.

BS EN 439, *Welding consumables — Shielding gases for arc welding and cutting*.

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

BS EN 719, *Welding co-ordination — Tasks and responsibilities*.

BS EN 910, *Destructive tests on welds in metallic materials — Bend tests*.

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

BS EN 1321, *Destructive test on welds in metallic material — Macroscopic and microscopic examination of welds*.

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

BS EN 1714:1998, *Non-destructive examination of welded joints — Ultrasonic examination of welded joints*.

BS EN 4105, *Nickel base alloy NI-B40002 (NiSi4B2) — Filler metal for brazing — Tape*.

BS EN 10160, *Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)*.

BS EN 12534, *Welding consumables — Wire electrodes, wires, rods and deposits for gas shielded metal arc welding of high strength steels — Classification*.

BS EN 13622, *Gas welding equipment — Terminology — Terms used for gas welding equipment*.

BS EN ISO 6507 (all parts), *Metallic materials — Vickers hardness test*.

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

PD 8010-1, *Code of practice for pipelines — Part 1: Steel pipelines on land*.

PD 8010-2, *Code of practice for pipelines — Part 2: Subsea pipelines*.

PD CR ISO 15608, *Welding — Guidelines for a metallic material grouping system*.

### 3 Terms and definitions

For the purposes of this British Standard, the terms and definitions given in BS 499-1:1991, BS EN 13622:2002 and the following apply.

#### 3.1

##### **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

#### 3.2

##### **buffer layer**

weld pass or passes, typically pure iron or pure nickel, separating the CRA and carbon steel parts of a weld

#### 3.3

##### **cap repair**

single run repair to the external surface of the original weld

#### 3.4

##### **cladding**

method whereby a CRA layer is metallurgically bonded to the pipe or fitting

#### 3.5

##### **contractor**

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

#### 3.6

##### **employer**

owner company or the engineering agency in charge of construction

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

#### 3.7

##### **full penetration repair**

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

#### 3.8

##### **internal back weld repair**

repair from the internal surface of the original weld

NOTE Sometimes referred to as "back weld repair".

#### 3.9

##### **joint**

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

#### 3.10

##### **lining**

method whereby a CRA shell is mechanically fixed within a pipe or fitting

#### 3.11

##### **mechanized welding**

welding process in which the welding parameters and torch guidance are controlled mechanically or electronically but may be manually varied during welding to maintain the required welding conditions

#### 3.12

##### **partial penetration repair**

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

**3.13****pipeline**

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

NOTE It does not include piping systems such as process plant piping within offshore installations.

[PD 8010-1 and PD 8010-2]

**3.14****positional welding**

welding wherein the pipe or assembly is held stationary

**3.15****preliminary welding procedure specification****pWPS**

proposed tentative welding procedure specification, prepared by the contractor for acceptance and approval by the employer but which is subject to qualification

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 (pWPS).

**3.16****qualification**

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

**3.17****re-repair**

second attempt at repairing a defect in the same location

NOTE For qualification purposes this is a repair of a repair, simulated by the sequence: original weld, excavate, repair, re-excavate and re-repair.

**3.18****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

[BS 499-1:1991]

**3.19****root run**

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

[BS 499-1:1991]

**3.20****seal weld**

weld used at the ends of lined pipe or fitting to close the gap between liner and substrate

**3.21****semi-automatic welding**

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

[BS 499-1:1991]

**3.22****sour service**

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

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

**3.23****substrate**

carbon steel section of the wall thickness onto which the CRA layer is applied

### 3.24

#### welder

operator who performs the welding  
[BS 499-1:1991]

### 3.25

#### welding procedure

specific course of action followed in welding, including a list of materials and, where necessary, tools to be used  
[BS 499-1:1991]

## 4 Information and requirements to be approved and documented

### 4.1 Information to be supplied 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 materials is required (see 7.1).
- b) Whether specific compositional controls are to be applied to the deposited weld metal (see 7.1).
- c) The degree of yield strength overmatching for welds in pipe materials where installation methods involve plastic deformation of the pipe or for welds in pipe of specified minimum yield strength 500–550 N/mm<sup>2</sup> (see 7.1).
- d) Whether different batches of electrodes and filler materials are to be individually identifiable and completely separated (see 7.2).
- e) The type and number of re-tests required in the event of failure during testing and qualification of welding procedures (see 8.1).
- f) Whether an alternative location is specified for the excavation location for the repair weld test (see BS EN 288-9:1999, Figure A.1, Figure A.2 and Figure 1, see also 8.1).
- g) Whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe-reeling (see 8.1).
- h) Whether specimens should be allowed to cool for a duration other than 24 h before testing (see 8.1).
- i) The method of weld tensile testing when a minimum weld metal yield strength required is specified (see 8.3.2).
- j) Charpy toughness and test temperature for conditions other than pipe and wall thicknesses up to and including 25 mm, minimum design temperatures not lower than –10 °C and pipe material with a specified minimum yield strength not greater than 550 N/mm<sup>2</sup> (see 8.3.5).
- k) Whether additional non-destructive testing (NDT) methods for fillet welds apply (see 9.1).
- l) Whether the hardness values of test specimens exceed those given in Table 4 (see 9.2.4.1).
- m) Whether a proposed change to a welding procedure or equipment requires requalification of the welders (see 10.5).
- n) Whether prevailing weather conditions are such that quality of the completed weld would be impaired (see 11.9)<sup>1)</sup>.
- o) The method(s) and frequency of visual inspection and NDT (see 12.1).
- p) Whether completed welds are to be ground (see 12.1).
- q) Whether alternative techniques are to be used for radiographic testing of welded butt joints (see 12.4.1).
- r) Ultrasonic testing acceptance criteria (see 12.5.3).
- s) Whether NDT acceptance criteria are to be based on quality control or engineering critical assessment (see 13.1.1).

<sup>1)</sup> Information for this item might not be able to be supplied until the appropriate stage of the work is reached.

- t) Whether the maximum planar defect dimension is to be less than 25 mm (see **13.1.2**).
- u) Whether a more stringent limit for root penetration is required [see Table 6 flaw type c)].
- v) Whether different hardness limits for anode bonding joints are required for anode bonding joints (see **B.2**).
- w) The composition and thickness of the pipe CRA layer (see **G.2.1**).
- x) The method of line pipe manufacture, including seal weld and longitudinal weld details where these items are present in CRA clad and lined pipelines (see **G.2.1**).
- y) The maximum oxygen content of backing gas during welding or the corrosion tests that the weld is required to pass (see footnote g Table G.1 and **G.6.4**).
- z) Whether the strength contribution of the CRA layer has been used in the design (see **G.3.3.1**).
- aa) Whether additional hardness traverses are required in CRA clad and lined pipelines (see **G.3.3.3**).
- ab) Hardness limits for CRA portions of the weldment (see **G.3.3.3** and **G.4.3**).
- ac) The composition limits for chemical analysis of the weld in CRA clad and lined pipelines (see **G.3.3.6**).
- ad) Whether a chemical analysis is required for seal weld qualification CRA clad and lined pipelines (see **G.4.4**).
- ae) Whether internal weld or cutting spatter in CRA clad and lined pipelines requires removal and the method to be used (see **G.6.1**).
- af) Whether weld root acceptance criteria more onerous than those in Table 5 are required in CRA clad and lined pipelines (see **G.8.1**).
- ag) Whether full penetration repairs are permitted in CRA clad and lined pipelines (see **G.8.3**).

#### 4.2 Items subject to approval by the employer

The following items to be subject to approval by the employer are specified in the clauses referred to and 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) Welding 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) The tensile strength of weld metal for joints between dissimilar materials if other than that of the higher strength parent metal (see **7.1**).
- d) The type and number of re-tests of a welding procedure when they are permitted (see **8.1**).
- e) Test weld production on pipes shorter than full length (see **8.1**).
- f) Use of roll welding (see **8.1**).
- g) Use of a test weld for destructive testing or rewelding to the same procedure following NDT failure (see **8.1**).
- h) Welding procedure qualification test details and welding procedure specification for production welding (see **8.1**).
- i) Simulation of a fillet weld joint using flat plate fillet welds [see **10.4.1b**].
- j) Alternative methods of NDT for welder test pieces [see **10.6c**].
- k) Giving a welder a second opportunity to gain approval (see **10.8**).
- l) All documentation relating to welder qualification tests (see **10.9**).
- m) Use of manual thermal cutting for pipe end bevelling and the ability of the operator (see **11.2**).
- n) The blending out by grinding of minor imperfections within the joint preparation area [see **11.2a**].
- o) Method of marking datum points on a joint for ultrasonic testing (see **11.2**).
- p) Method of obtaining minimum misalignment other than rotation of the pipes (see **11.4**).
- q) Method of alignment of pipes other than internal line-up clamps (see **11.5.1**).
- r) The stage at which line-up clamps are removed (see **11.5.1**).

- s) The stage at which the pipe is lowered onto skids, or support is removed from fittings (see **11.5.2**).
- t) Repair of places where stray arcs have occurred (see **11.8**).
- u) Means of applying preheat (see **11.10.2**).
- v) Methods of attaching and removing thermocouples (see **11.10.4**).
- w) The welding procedure for branch connections where the angle between the main and branch is less than 60° (see **11.11.1**).
- x) Written ultrasonic examination procedure for pipe material around a planned cut-out (see **11.11.3**).
- y) All NDT procedures to be used for inspection and testing (see **12.1**).
- z) All inspection personnel (see **12.2**).
- aa) The technique in BS EN 1435 to be used for radiographic examination (see **12.4.1**).
- ab) Any method for magnetic particle testing to be used at above ambient temperature [see **12.7a**].
- ac) Any proposal to repair a weld (see **13.2.1**).
- ad) Any alternative limits on repair weld length (see **13.2.1**).
- ae) Use of root sealing or single run repair deposits (see **13.2.4**).
- af) More than one attempt at a repair (see **13.2.4**).
- ag) The position of the longitudinal seam weld (if applicable) on the subsea pipeline at the hyperbaric weld location (see **A.9.2**).
- ah) Joining technique and equipment for brazing and aluminothermic welding of anode bonding leads (see **B.1**).
- ai) Proposed brazing and aluminothermic welding procedure specification (see **B.2**).
- aj) Method of chemical analysis of butt welds in CRA clad and lined pipelines (see **G.3.3.6**).
- ak) The location, elements to be analysed, method and acceptance criteria for seal weld chemical analysis in CRA clad and lined pipelines (see **G.4.4**).
- al) Whether grinding, wire brushing or filing of the internal surface of CRA clad and lined pipelines is permitted (see **G.6.1**).
- am) Cessation of oxygen monitoring immediately prior to completion of the root pass in CRA clad and lined pipelines (see **G.6.4**).
- an) The method of flaw removal in CRA clad and lined pipelines (see **G.8.2**).
- ao) A reduction in the number of mechanical test samples for qualification of repair weld procedures in CRA clad and lined pipelines (see **G.8.3**).

## **5 Equipment**

Welding equipment shall be calibrated and maintained in a condition that allows production of acceptable welds, continuity of operation and safety of personnel. Equipment that does not meet this requirement shall be either repaired or replaced.

Arc welding equipment shall be capable of operating within the amperage and voltage ranges specified in the approved WPS.

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

The welding equipment shall be capable of controlling the parameters given in Table 1 item b) to within the limits stated.

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

Pipe handling equipment, rollers and line-up clamps shall be such that they avoid damage to the pipe, ensure that pipe axes are aligned in accordance with 11.4 and allow the welding procedure to be used.

For installation methods involving plastic deformation of the pipe, the installation equipment shall be capable of controlling the curvature of the pipe and the amount of displacement controlled strain.

## 6 Welding processes

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

## 7 Welding consumables

### 7.1 General

Only welding consumables which have received the prior approval of the employer shall be used, see 4.2a). When specified by the employer [see 4.1a)], 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 [see 4.2b)].

The chemical composition of the deposited weld metal shall be selected to ensure adequate resistance to degradation from the pipeline contents under the intended operating conditions. The employer shall indicate whether specific compositional controls are to be applied to meet these requirements, see 4.1b).

When tested in accordance with 8.3 the weld metal produced by electrodes, filler wires and shielding gases, and wire/flux combinations shall have a tensile strength at least equal to the minimum specified for the parent metal.

Unless an alternative value is approved by the employer [see 4.2c)], when tested in accordance with 8.3 the weld metal of joints between dissimilar materials shall have a tensile strength at least equal to that specified for the higher strength parent metal.

When tested in accordance with 8.3 the weld metal yield strength of welds in pipe material of specified minimum yield strength (550–555 N/mm<sup>2</sup>), or for all pipe grades where installation methods involving plastic deformation of the pipe shall be greater than the minimum specified for the parent material. For these cases, the degree of yield strength overmatching required shall be specified by the employer [see 4.1c)].

Shielding gases shall be in accordance with BS EN 439.

NOTE 1 In selecting the level of weld metal overmatching, consideration should be given to actual yield and tensile strength of the linepipe to be welded in production.

NOTE 2 Appropriate electrodes and filler materials conforming to 7.1 are specified in BS EN 499, BS EN 1599, BS EN 757, BS EN 758, BS EN 756, BS EN 760 and BS EN 12534. Carbon dioxide used as a shielding gas should conform to BS 4105.

NOTE 3 When welding pipe material of specified minimum yield strength (550–555 N/mm<sup>2</sup>), i.e. X80 grade, it is recommended that if cellulosic coated electrodes are used they are restricted to the root and hot pass only.

### 7.2 Storage and handling

Different grades and, when specified by the employer [see 4.1d)], different batches of electrodes and filler materials shall be individually identifiable and be completely separated. Electrodes shall be stored in accordance with the manufacturer's 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, for example coating breakage, 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.

Gases may be mixed in the field 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 for butt welds

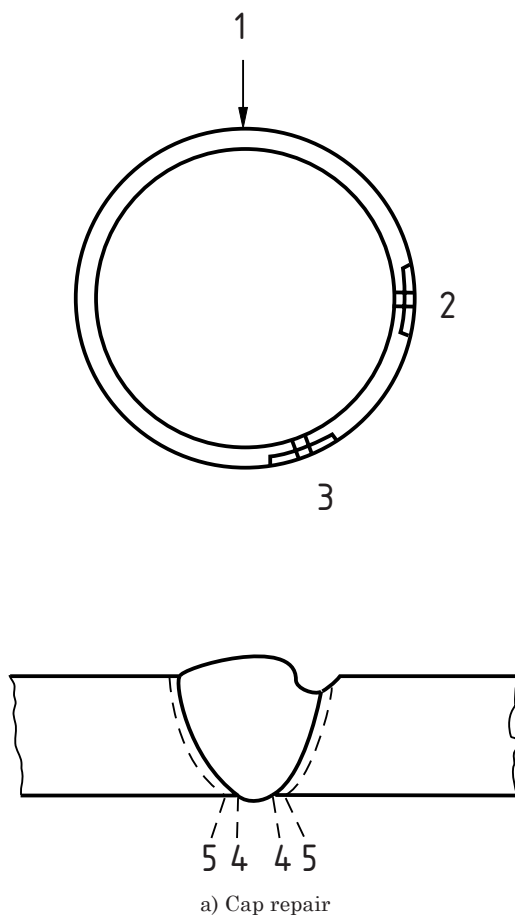
### 8.1 General

Testing, qualification and approval of welding procedures for butt welds shall either be in accordance with BS EN 288-9 and 8.2, 8.3 and 8.4, which also apply to repair welds, or in the event of a failure, the type and number of such re-tests shall be specified by the employer, see 4.1e) and 4.2d).

The test weld shall be produced in accordance with the proposed welding procedure specification (WPS) under simulated site conditions on full pipe lengths unless other pipe lengths are approved by the employer [see 4.2e)].

Repair welds shall be made using a sample of the original weld excavated to a suitable profile and depth, with the excavation located as close as possible to the position shown in BS EN 288-9:1999, Figure A.1 or Figure A.2 for full penetration and internal single run repairs, and the position shown in Figure 1a), Figure 1b) and Figure 1c) for all other types of repair, or as specified by the employer [see 4.1f)].

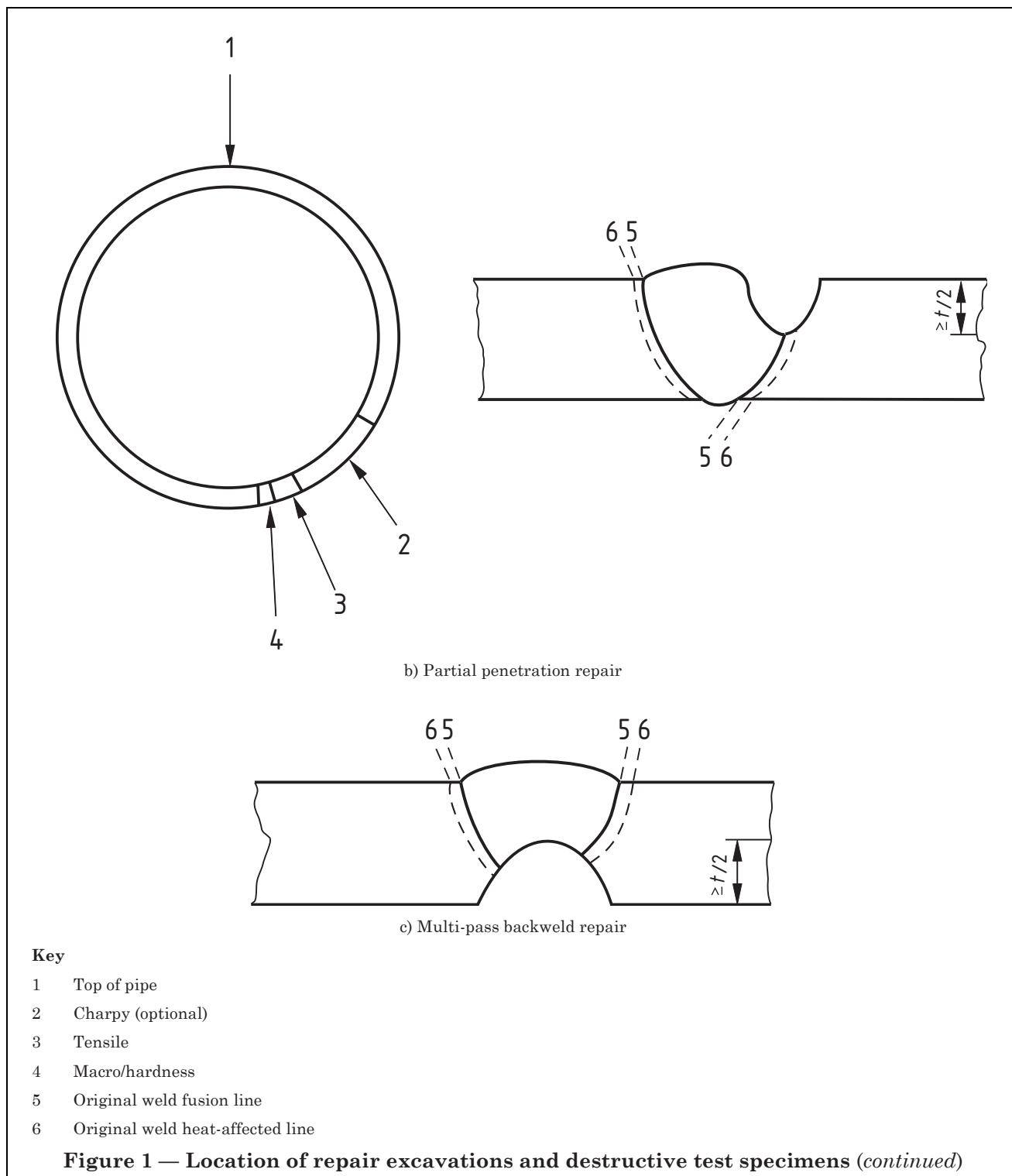
Roll welding shall only be used with the employer's approval [see 4.2f)] and when it can be demonstrated that the joint can be adequately supported to maintain its axial alignment.



#### Key

- 1 Top of pipe
- 2 Vertical down welding, macro/hardness
- 3 Vertical up welding, macro/hardness
- 4 Original weld fusion line
- 5 Original weld heat-affected line

**Figure 1 — Location of repair excavations and destructive test specimens**



When a welding procedure is to be qualified and approved for installation processes involving plastic deformation, the welding procedure details shall include relevant previously-documented strain ageing data and/or any additional tests specified by the employer to characterize any possible degradation in properties. See 4.1g).

NOTE 1 Strain ageing tests are typically applied to Charpy specimens and might include representative strain cycles and accelerated ageing typically for 1 h at 100 °C for pipelines operating at less than 80 °C, or 250 °C for pipelines operating at higher temperatures.

NOTE 2 For installation processes involving plastic deformation, it might be necessary to implement additional controls for welds, in order to avoid the possibility of unstable fracture during installation or the stable extension of flaws to an extent that would be detrimental to the future operation of the pipeline. This should include consideration of all sources of strain concentration at the girth weld, for example, geometric mismatch, differences in pipe strength, weld over/under matching and variations in coating stiffness.

The quality of the test welds shall be determined by non-destructive and destructive testing after specimens have been allowed to cool to ambient temperature in simulated site conditions for 24 h unless an alternative duration is specified by the employer, see 4.1h).

If NDT indicates the presence of flaws exceeding the levels permitted in 13.1, the reason shall be investigated and an explanation provided to the employer before they may approve the use of this test piece for the purposes of destructive testing or alternatively re-welding the test piece using the same specification/procedure [see 4.2g)].

The contractor shall submit recorded details for each welding procedure qualification test and the WPS for production welding to the employer for approval [see 10.9 and 4.2h)].

NOTE 3 Examples of welding procedure specification forms which should be used are given in Annex C.

NOTE 4 When welding procedure qualification tests have been carried out in accordance with BS 4515-1 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 8.2.

## 8.2 Changes affecting qualification and approval (essential variables) of butt welds

The changes affecting approval (essential variables) of the WPS shall be in accordance with Table 1 and BS EN 288-9:1999, Clause 8. For repair welds in group 1 materials in accordance with PD CR ISO 15608, a repair procedure shall be qualified if it is outside the range of approval given in Table 1 and BS EN 288-9:1999, Clause 8.

For group 2 and 3 steels in accordance with PD CR ISO 15608, full penetration repairs and single run repairs shall require qualification and approval.

Partial penetration repairs shall only require procedure test welding when the pWPS contains changes affecting the qualification of the original welding procedure as specified in Table 1 and BS EN 288-9:1999, Clause 8.

Re-repair procedures shall only be qualified and approved if Charpy testing is required or if there are any changes affecting the qualification of the original welding procedure as specified in Table 1 and BS EN 288-9:1999, Clause 8.

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

| Item                            |    | Welding procedure specification details                                       | Changes affecting approval (essential variables)                        |
|---------------------------------|----|-------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Electrode or filler materials   | a  | Trade name                                                                    | Any changes when Charpy testing is required                             |
| Welding parameters <sup>a</sup> | b1 | Electrical stick-out (SAW, MAG, FCAW) <sup>b</sup>                            | Any change exceeding $\pm 5$ mm                                         |
|                                 | b2 | Arc voltage <sup>b</sup>                                                      | Any change exceeding $\pm 10$ %                                         |
|                                 | b3 | Wire feed speed (SAW, MAG, FCAW) <sup>b</sup> or welding current <sup>c</sup> | Any change exceeding $\pm 10$ % ( $\pm 15$ % for cellulosic electrodes) |
|                                 | b4 | Travel speed <sup>b</sup>                                                     | Any change exceeding $\pm 10$ %                                         |
|                                 | b5 | Calculated value of heat input <sup>b c</sup>                                 | No separate restriction                                                 |
| Direction of welding            | c  | Vertical up, vertical down or horizontal                                      | Any change                                                              |

<sup>a</sup> The information is needed for each wire size, different values may be used for different runs. These items shall be specified on the proposed WPS but are not mandatory for the production WPS if they are controlled through other procedures.

<sup>b</sup> These parameters shall be specified as single nominal values on the proposed WPS but as qualified ranges (nominal values  $\pm$  permitted variation) on the production WPS. In cases where the mean value measured in qualification differs from the nominal value, the qualified range shall be calculated from the mean value measured in qualification.

<sup>c</sup> These items shall be specified on the proposed WPS but are not mandatory for the production WPS if they are controlled through other procedures.

### 8.3 Destructive testing of butt welds and full penetration repair welds

#### 8.3.1 Transverse weld tensile testing

Transverse tensile testing of butt welds and full penetration repair welds shall be in accordance with BS EN 288-9:1999, 7.4.1 and the following.

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

b) Any specimen that breaks outside the weld or fusion zone at a tensile strength less than 95 % of the specified minimum tensile strength of the pipe material shall be rejected. 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 or fusion zone at a tensile strength below the minimum stated above, the pipe material should be considered to be suspect and its physical properties investigated before any additional joints are made.

c) Weld specimens made in pipe material of specified minimum yield strength (550–555 N/mm<sup>2</sup>) or where installation methods involve plastic deformation of the pipe shall break outside the weld or fusion line to be deemed acceptable.

#### 8.3.2 Weld metal tensile testing

When a minimum weld metal yield strength requirement is specified, i.e. for welds in pipe material of specified minimum yield strength (550–555 N/mm<sup>2</sup>) or where installation methods involve plastic deformation of the pipe (see 7.1), all weld tensile testing shall be performed in accordance with the method specified by the employer [see 4.1i)].

#### 8.3.3 Macro-examination

Macro-examination of butt welds and full penetration repair welds shall be in accordance with BS EN 288-9:1999, 7.4.2 and the following additional specimens shall be tested.

a) For upwards welding, macro-examination at the 12 o'clock and 3 o'clock positions.

b) For downwards welding, macro-examination at the 6 o'clock and 12 o'clock positions.

#### 8.3.4 Hardness

Hardness testing of butt welds and full penetration repair welds shall be in accordance with BS EN 288-9:1999, 7.4.4 and the following:

a) for sour service it shall also be carried out at the 3, 6 and 12 o'clock positions.

b) for non-sour service, the maximum permitted weld metal hardness shall be 300 HV10 when welding pipe material with a specified minimum yield strength of 550–555 N/mm<sup>2</sup> (i.e. X80 grade). This hardness limit shall not however apply to the root region of manual welds when cellulosic electrodes are employed.

NOTE For mechanized welds, because of their generally narrower heat affected zones, consideration should be given to using a lower indenting load e.g. 5 kg.

#### 8.3.5 Impact testing

Impact testing of butt welds and full penetration repair welds shall be in accordance with BS EN 288-9:1999, 7.4.3 and additional Charpy tests shall be carried out at the 12 o'clock position, notched at the weld centre line and the weld fusion line. When tested at the minimum design temperature, all Charpy impact test specimens shall have an average not less than 40 J and a minimum individual value of 30 J. The requirements for sub-size specimens shall be reduced pro rata with their dimensions.

The Charpy impact test requirements shall apply for pipe and wall thicknesses up to and including 25 mm, minimum design temperatures that are not lower than –10 °C and pipe material with a specified minimum yield strength not greater than 555 N/mm<sup>2</sup> (i.e. X80 grade). Charpy toughness and test temperature for other conditions shall be specified by the employer [see 4.1j)].

When these Charpy requirements are met, the flaw acceptance criteria in Table 6 may be used. Derivation of alternatives for criteria through an ECA approach shall be in accordance with 13.1.3.

NOTE Attention is drawn to the publications by the *European Pipeline Research Group* [2] and [3].

8.4 Destructive testing of partial penetration and single run repair welds

8.4.1 Test specimens

Test specimens for destructive testing for partial penetration and single run repair welds shall be cut from the repair test weld at the locations shown in Figure 1a), Figure 1b) and Figure 1c).

The minimum number of specimens and destructive testing carried out shall be in accordance with Table 2.

When required by the employer for the qualification of the original welding procedure, Charpy impact testing shall also be carried out on repair procedures.

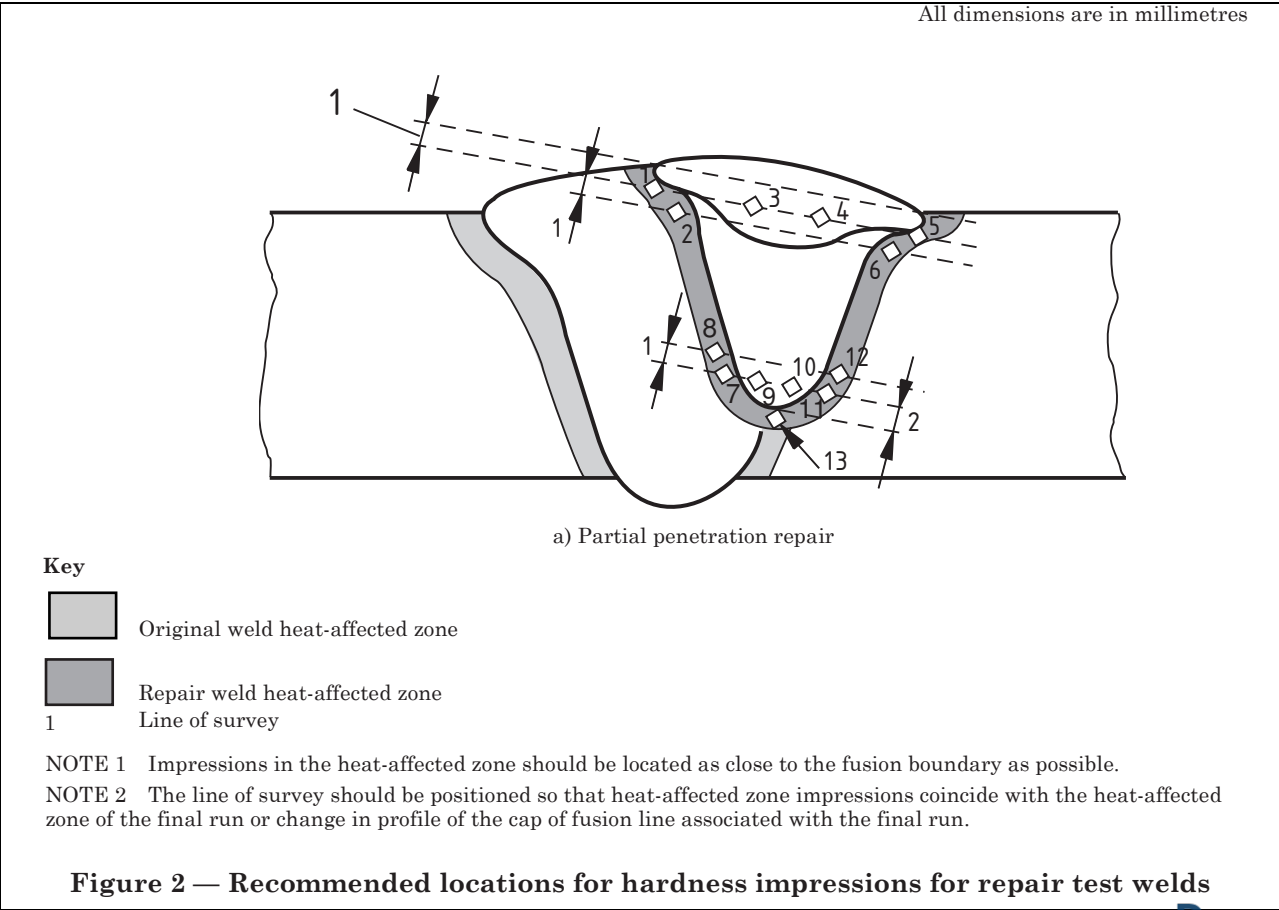
Table 2 — Number of test specimens to undergo destructive testing for weld repair procedure qualification

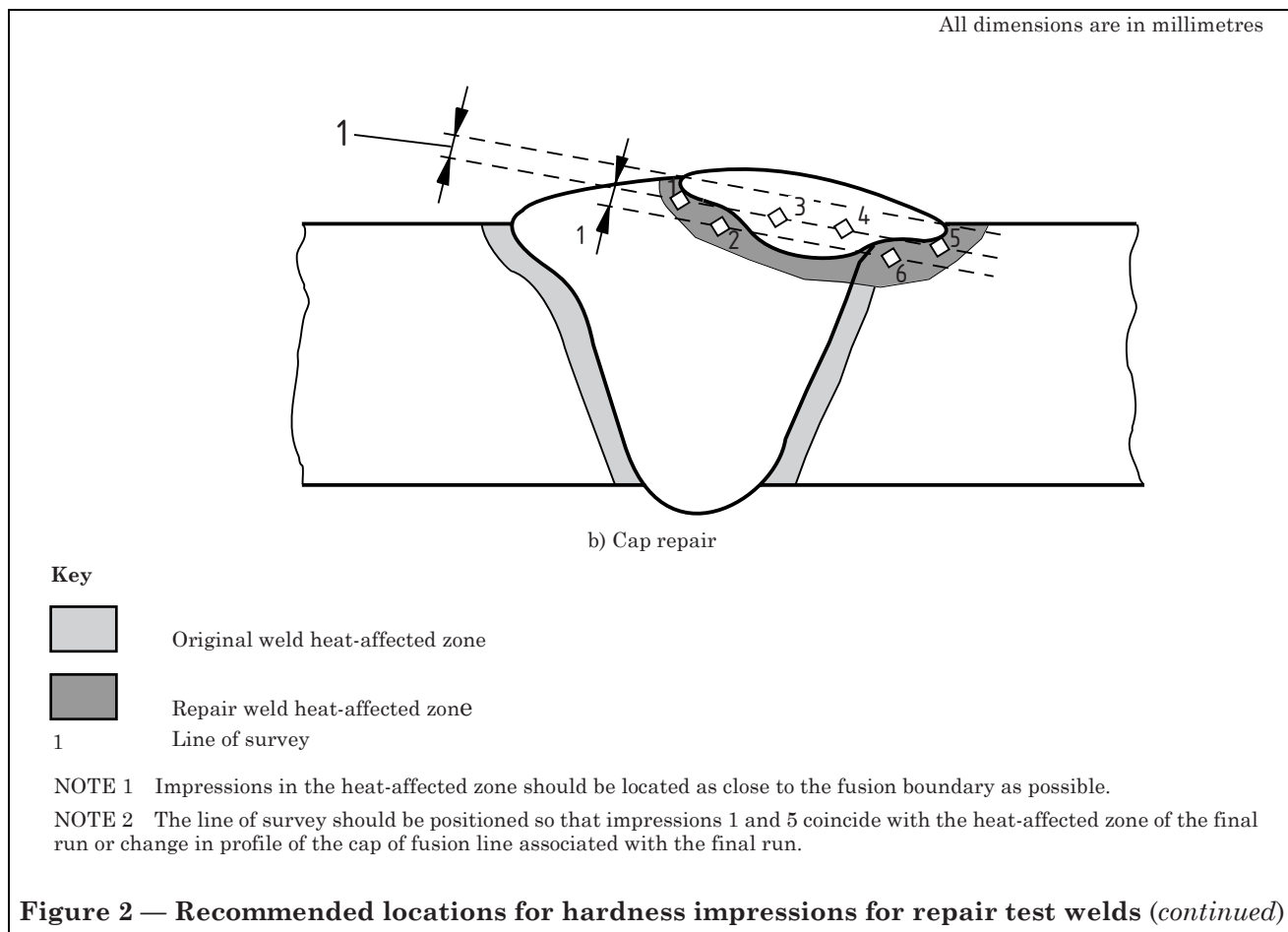
| Weld repair procedure                                     | Number of specimens             |                   |                              |                          |
|-----------------------------------------------------------|---------------------------------|-------------------|------------------------------|--------------------------|
|                                                           | Transverse tensile <sup>a</sup> | Macro-examination | Hardness survey <sup>b</sup> | Charpy test <sup>c</sup> |
| Partial penetration repair and multi-pass backweld repair | 1                               | 1                 | 1                            | 3 sets of 3              |
| Re-repair                                                 | 1                               | 1                 | 1                            | 2 sets of 3 <sup>d</sup> |
| Cap repair                                                | N/A                             | 1                 | 1                            | N/A                      |
| Backweld repair                                           | N/A                             | 1                 | 1                            | N/A                      |

<sup>a</sup> Not required if tested as part of the original procedure.  
<sup>b</sup> The hardness survey is carried out on the macro-examination test specimen.  
<sup>c</sup> When required by the employer for qualification of the original welding procedure.  
<sup>d</sup> Over 20 mm thickness a third set is required.

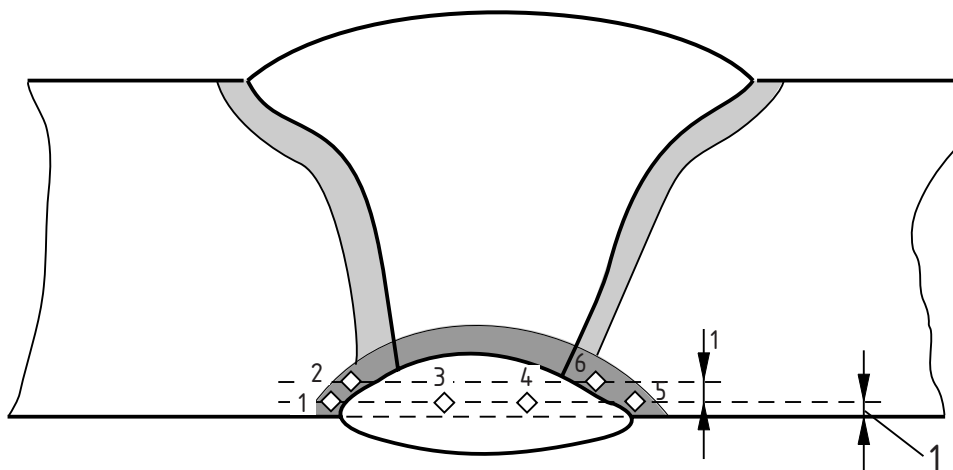
8.4.2 Hardness

Hardness testing of partial penetration and single run repair welds shall be in accordance with 8.3.3 and the impressions shall be located as shown in Figure 2a), Figure 2b), Figure 2c) and Figure 2d).

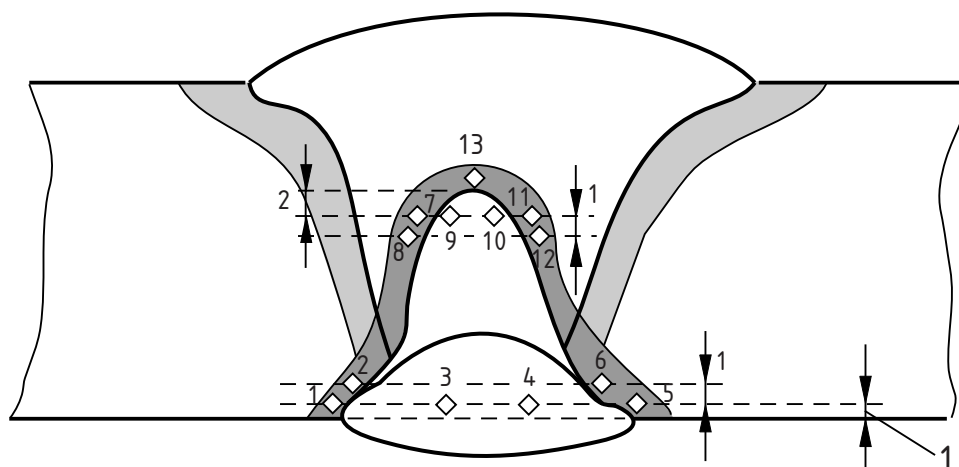




All dimensions are in millimetres



c) Single pass backweld repair



d) Multi-pass backweld repairs

**Key**

-  Original weld heat-affected zone
-  Repair weld heat-affected zone
- 1 Line of survey

NOTE 1 Impressions in the heat-affected zone should be located as close to the fusion boundary as possible.

NOTE 2 The line of survey should be positioned so that impressions 1 and 5 coincide with the heat-affected zone of the final run or change in profile of the cap of fusion line associated with the final run.

**Figure 2 — Recommended locations for hardness impressions for repair test welds (continued)**