

Specification for

Welding of steel pipelines on land and offshore —

Part 2: Duplex stainless steel pipelines

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Committees responsible for this British Standard

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- 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.)

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Foreword

This British Standard has been prepared by Subcommittee WEE/21/7. It complements BS 4515-1¹⁾ 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 8.1b);
- d) whether strain ageing data and/or additional tests are required as the basis for welding procedure approval for pipe-reeling (see 8.1e);
- e) the type and number of re-tests required in the event of a procedure test failure (see 8.1f)²⁾;
- f) whether any additional methods of non-destructive testing are required for butt joints (see 8.5.1b);

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 9.5i);
- 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 8.1b);
- e) explanation for NDT failure if a test weld is to be destructively tested or re-welded to the same procedure (see 8.1d);
- 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 9.4.1b);
- 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.

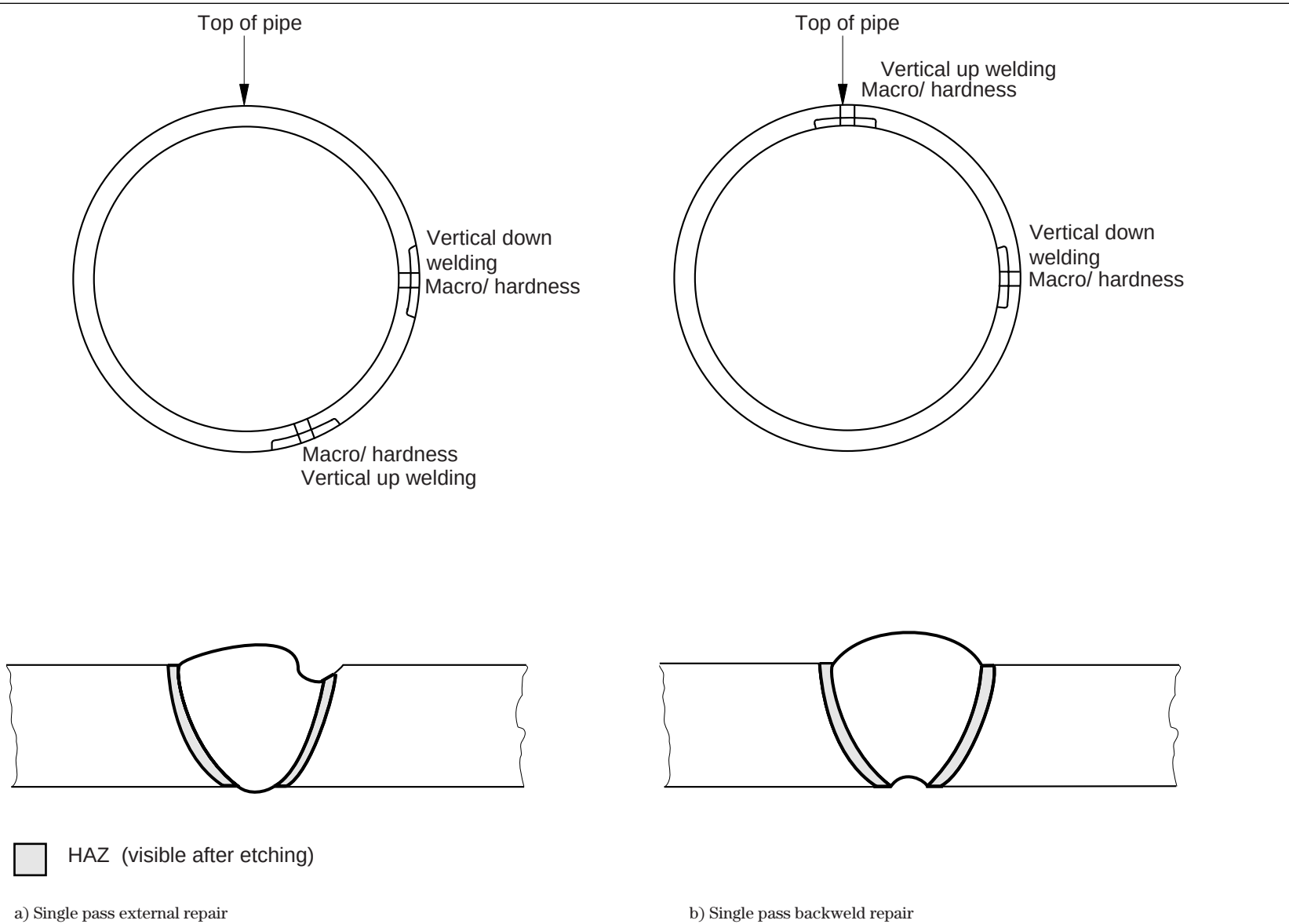


Figure 1 — Location of repair excavations and destructive test specimens

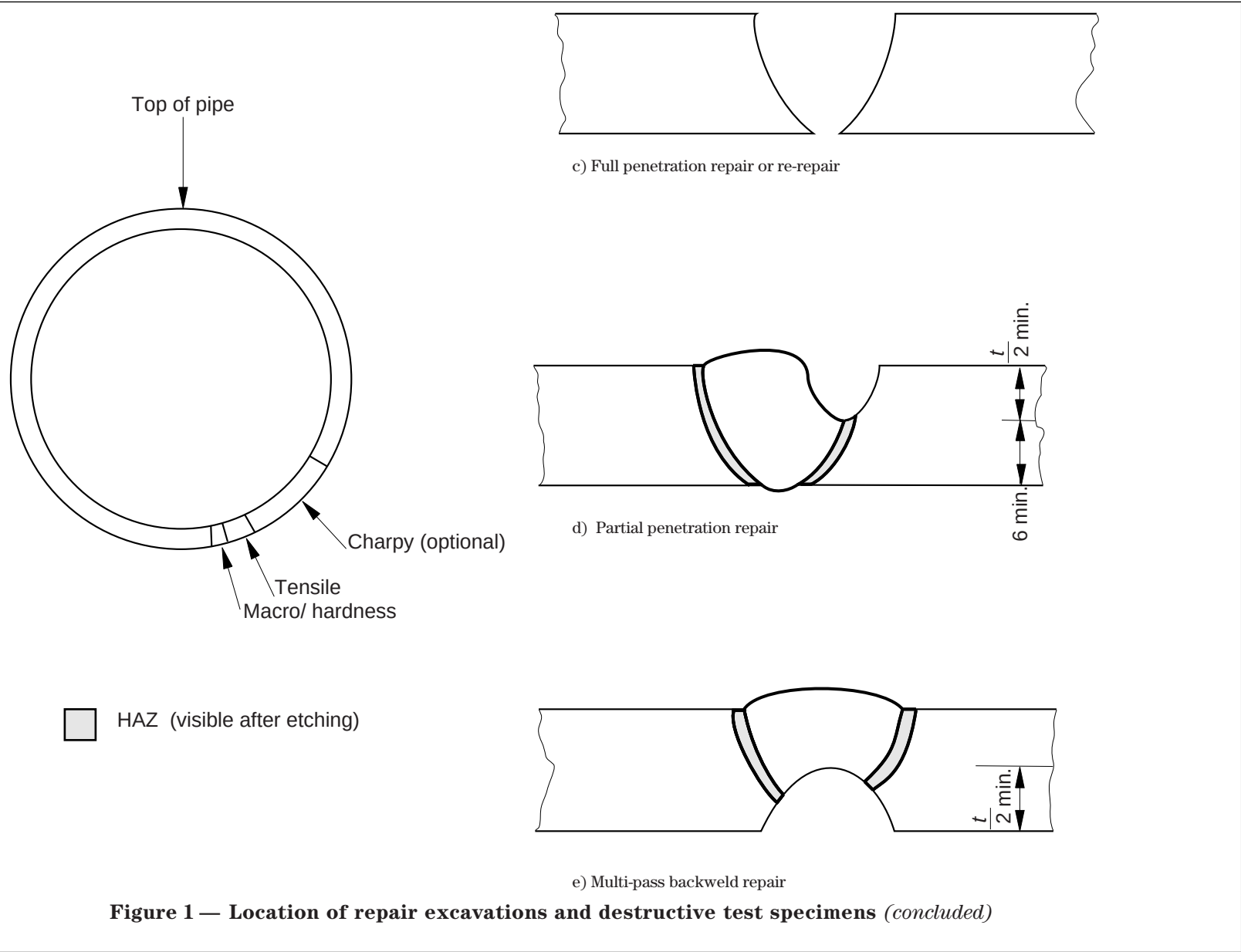


Figure 1 — Location of repair excavations and destructive test specimens *(concluded)*