

BS 4515 : 1984

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(Reprinted incorporating Amendment No. 1)

British Standard Specification for
Welding of steel pipelines
on land and offshore

Soudage des canalisations en acier à terre et en mer — Spécification

Schweißen von Stahlrohrleitungen an Land und auf Bohrinseln

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Amendment No. 1
published and effective from 23 December 1987
to **BS 4515 : 1984**

**Specification for process of welding of steel
pipelines on land and offshore**

Revised text

AMD 5810
December 1987

Title

On the front cover and on page 2, delete 'Process of welding' and substitute 'Welding'.
In the French title, delete 'Procédés de soudage' and substitute 'Soudage' and delete 'Spécification' and substitute 'Spécifications'.
In the German title, delete 'Verfahren für das'.

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December 1987

Contents

Against the entry for 'Foreword', delete 'Inside front cover' and substitute '1'.
Under 'Tables' delete the entry for table 7 and substitute the following:
'7. Impact specimen sizes, test temperatures and values of factor F '.
Under 'Figures' delete the entry for figure 20 and substitute the following:
'20. Positioning of Charpy specimen V-notch for procedure approval of partial penetration repair welds'.
After the entry for figure 21 insert the following:
'22. Position of CTOD specimen notch for assessing original weld'.

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Foreword

After paragraph 5 insert the following new paragraph:
'*Pipe dimensions.* Unless otherwise qualified, for the purposes of this British Standard nominal values of outside diameter and thickness of pipe apply.'

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Clause 1 Scope

In paragraph 1, lines 1 and 2, delete 'process of'.

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Clause 3.1 Information to be supplied by the employer

Delete items (f), (g) and (h) and substitute the following:

- '(f) Whether Charpy impact and/or CTOD tests are required for welding procedure approval of butt joints (see 13.2.1).
- (g) The number of test specimens required for Charpy impact tests on pipes of diameter 114.3 mm or less (see 13.2.1).
- (h) Values of impact energy if other than those derived from table 7 (see 13.2.5.1).'

Delete item (j) and substitute the following:

'(j) Whether the crack tip opening displacement (CTOD) approach is to be used to derive weld acceptance criteria (see 13.2.6.1.1).'

Delete item (s) and substitute the following:

'(s) Where the pipe curvature is to be machined for CTOD testing (see H.4.3(b)).'

After item (s) insert the following new items:

'(t) The minimum design temperature.

(u) Whether re-tests of a welding procedure are permitted (see clause 8(f)).

(v) The number of transverse tensile test specimens required for welding procedure testing on pipes up to and including 114.3 mm diameter (see 13.2.1).

(w) Values for CTOD as alternative to Charpy values if other than those determined from figures 8 to 15 (see 13.2.6.1.2).

(x) Any other change in a welding procedure which would make production of a sound weld more difficult for the welder (see 15.5(h)).'

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December 1987

Clause 3.2 Items to be approved by the employer

Delete items (v), (w), (x) and (y) including the notes and substitute the following:

'(v) Use of root sealing or single run repair deposits (see 42.4).

NOTE. The approval of the statutory authority may also be required.

(w) Number of repair attempts if more than one (see 42.4).

NOTE. The approval of the statutory authority may also be required.

(x) The laboratory to be used for carrying out CTOD tests (see H.4.4).

(y) The type and number of re-tests of a welding procedure when they are permitted (see clause 8(f)).

(z) The notch locations for Charpy specimens when root sealing or single run repairs are used (see 13.2.5.3).'

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December 1987

Clause 3.3 Requirements to be agreed

Delete item (d) and substitute the following:

'(d) Use of alternative hardness values to those given in table 6 (see 13.2.4.1(b) and 14.2.4.1(b)).'

Delete the existing item (n) and substitute the following new items:

'(n) The definition of a batch when batch testing of electrodes and filler materials is required (see 6.1).

(o) The use of different agreed diameter and thickness groupings from those given in table 3(c) (see clause 10(c)).

(p) The use of three further specimens when the lowest value from a set fails to meet the minimum CTOD requirement (see H.5(c)).'

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Clause 4. Equipment

After paragraph 2 insert the following new paragraph:

'The welding equipment shall be capable of controlling the parameters given in table 4 to within the limits stated in that table.'

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Clause 6.1 General

In paragraph 4 delete the last sentence and substitute the following:

'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 agreed between the contracting parties.'

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Clause 8. General

After item (e) insert the following new item (f):

'(f) In the event of failure in any of these tests, the procedure shall be rejected. If the employer permits re-tests, the type and number of such re-tests shall be approved by the employer.'

Re-designate previous paragraph (f) as '(g)'.

Delete the note and substitute the following:

'NOTE. When welding procedure approval 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 4.'

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Clause 9. Records

In line 4, delete '(see clause 13)' and substitute '(see clauses 13 and 14)'.

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Clause 10. Welding procedure

Delete paragraph 2 and substitute the following:

'Procedure approval tests shall be carried out on one of the following:

(a) pipe made from the same material and of the same outside diameter and thickness as that to be used in production;

(b) when approved by the employer, pipe made from the same material but of diameter and thickness from the same group given in table 3(c) as that to be used in production provided the components being joined are of the same dimensions in respect of both diameter and thickness;

(c) when agreed between the contracting parties, pipe made from the same material as that to be used in production but using different agreed diameter and thickness groupings from those given in table 3(c).

Separate welding procedures shall be formulated for repair welds, to cover both partial and full penetration removal of the original weld metal. The repair welding procedure shall be approved on test welds that simulate the type of repair.'

In paragraph 3 after the note, in line 3 after 'pipes', insert ', flanges and fittings'.

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Clause 11. Changes affecting approval (essential variables)

After the existing paragraph insert the following new paragraph:

'Unless a repair welding procedure contains changes affecting the approval of the original welding procedure, no re-approval shall be necessary. In all other cases the repair procedure shall be regarded as a new welding procedure and shall be fully re-approved.'

Table 3. Welding procedure details

For item (h) delete the entry in column 2 and substitute the following:

'Current (a.c. or d.c.) and polarity. Nominal settings for electrical stickout, voltage, current or wire feed speed, where these parameters are controlled directly. Settings to be given for each size of electrode or filler metal, and also where different settings are required for different runs with the same size of consumable.'

For item (u) delete the entry in column 2 and substitute the following:

'Run-out length or travel speed to be given for each size of electrode or filler metal and also where different values are required for different runs with the same size of consumable.'

Table 4. Changes affecting approval (essential variables)

For item (f) delete the entry in column 2 and substitute the following:

'Any change in the diameter used for the capping layer or the first two layers in the joint. Any change for other runs to a diameter larger than that approved for that run.'

For item (s) delete the entry in column 2 and substitute the following:

'Any change exceeding $\pm 10\%$ in the specified values of electrical stickout, voltage, current or wire feed speed, run-out length or travel speed, whichever of these is controlled directly. This range also defines the maximum permitted fluctuation in any of these controlled parameters.'

Clause 13. Testing of butt joints for procedure approval

Delete the complete clause and substitute the following:

13. Testing of butt joints for procedure approval

13.1 Non-destructive testing. All test butt joints shall be examined visually (see BS 5289) followed by either:

- (a) radiographic examination using technique nos. 8, 14 or 2 in that order (i.e. the preferred order) described in BS 2910; or
- (b) an alternative method or additional method agreed between the contracting parties (see 36.1).

NOTE. The agreement of the statutory authority may also be required.

The results from visual examination and non-destructive testing shall be assessed according to the appropriate acceptance criteria specified in clause 41.

13.2 Destructive testing

13.2.1 Test specimens. Test specimens shall be cut from the test joint at the locations shown in figure 1. The minimum number of specimens and the tests to which they shall be subjected shall be as given in table 5. For outside diameters of pipe up to and including 114.3 mm, the number of transverse tensile test specimens shall be specified by the employer.

When required by the employer, Charpy impact and/or CTOD testing shall be carried out. When Charpy impact tests are required, 12 test specimens shall be taken for pipes of outside diameter over 114.3 mm, but for pipes of outside diameter up to and including 114.3 mm the number of test specimens shall be specified by the employer. When required by the employer, CTOD testing shall be in accordance with 13.2.6.

NOTE 1. It may be necessary or advantageous to carry out more comprehensive testing than is required by this subclause (e.g. chemical analysis, micro-examination) in order to gain more information and to avoid having to repeat the welding procedure test at a later date just to obtain additional test data.

NOTE 2. When post-weld heat treatment is carried out, it may be necessary to verify the properties of the pipe and all welded joints affected by the heat treatment.

13.2.2 Transverse tensile test

13.2.2.1 Requirements. When tested as described in 13.2.2.2, the tensile strength of the joint, including the fusion zone of each specimen, 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 or fusion 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 or fusion 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 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 should be investigated before any additional joints are made.

13.2.2.2 Method. The test specimens shall have the shape and dimensions shown in figure 2. Machine the weld reinforcement flush with the pipe surface for material with a specified minimum tensile strength of 500 N/mm² or above (e.g. API 5L grade X60 or higher). Prepare the specimens by machine cutting or by thermal cutting. If the latter method is used, subsequently dress the affected areas by grinding. In all cases, 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 as described in BS 18 : Part 2. 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 the temperature of testing.

13.2.3 Macro-examination

13.2.3.1 Requirements. When tested as described in 13.2.3.2, the specimens shall be free from cracks and lack of fusion. Any other defects shall be within the limits specified in clause 41.

13.2.3.2 Method. Cut transverse sections, suitable for examination of the weld and adjacent parent metal and for a hardness survey, as close as possible to the locations shown in figure 1 but at positions shown to be free from defects after non-destructive testing in accordance with 13.1.

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

13.2.4 Hardness survey

13.2.4.1 Requirements. When tested as described in 13.2.4.2, the hardness values shall not exceed either:

- (a) those given in table 6; or
- (b) those agreed between the contracting parties.

NOTE. The agreement of the statutory authority may also be required.



13.2.4.2 Method. Use one of the sections for macro-examination for the hardness survey. For vertical-down welding, take the section from the 3 o'clock position and for vertical-up welding, take the section from the 6 o'clock position. Test the sections as described in BS 427 preferably using a 10 kg load, although a 5 kg load will often be necessary for the narrow heat-affected zones in some welds made by mechanized processes. Make two weld zone traverses, one across the root and one across the cap region of the weld. For pipe 16 mm or over in thickness, make an additional traverse midway between the other two. Each traverse shall consist of at least eight impressions: two in each heat-affected zone, two in the weld metal and one in the parent metal each side of the weld.

NOTE. The recommended locations for the impressions are shown in figure 3(a) for an original weld and in figure 3(c) for a repair weld.

13.2.5 Charpy V-notch impact test

13.2.5.1 Requirements. When impact tests are required by the employer, the minimum average value and minimum individual value of impact energy for each set of three specimens, when tested as described in 13.2.5.2 for an original weld or 13.2.5.3 for a repair weld shall be not less than either:

(a) the values derived from the following expression using the value of factor F given in table 7 for the appropriate thickness of material:

$$\text{impact energy} = \frac{\text{specified minimum yield stress}}{F}$$

or

(b) the values specified by the employer according to design and operational conditions.

NOTE 1. Impact tests would not normally be required for pipelines having a design temperature of 10 °C or higher.

NOTE 2. When it is not possible to meet the requirements of 13.2.5.1, the use of CTOD testing may also be considered for welding procedure approval subject to agreement between the contracting parties (see 13.2.6.1.2).

13.2.5.2 Method for original procedure. Machine, transverse to the weld, two sets of three Charpy V-notch test specimens from each location shown in figure 1. At each location take one set of three specimens so that the notch is in the vertical centre of the weld metal and take the other set of three specimens so that the fusion line of the heat-affected zone passes through the centre of the vertical notch. For pipe of thickness up to and including 20 mm, the specimens shall be located at mid-wall thickness. For pipe of thickness over 20 mm, one set of specimens at the 3 o'clock position shall be positioned at the weld root as shown in figure 4.

The exact size of the specimens depends on the pipe thickness but the largest possible size shall be selected from those given in table 7. Machine, notch and test the specimens as described in BS 131 : Part 2, testing being at the appropriate temperature given in table 7.

13.2.5.3 Method for repair procedure. Full penetration repairs shall be tested in accordance with 13.2.5.2.

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

The notch locations for root sealing or single run repairs shall be subject to approval by the employer.

The exact size of the specimens depends on the pipe thickness but the largest possible size shall be selected from those given in table 7. Machine, notch and test the specimens as described in BS 131 : Part 2, testing being at the appropriate temperature given in table 7.

13.2.6 Crack tip opening displacement (CTOD) testing

NOTE 1. If it is not possible to obtain the total number and type of test specimens from the circumference of a single test joint, then a further joint should be welded for test purposes.

NOTE 2. When production welds are likely to be stressed very shortly after welding is completed, e.g. as on a laybarge, CTOD testing of a weld for procedure approval should be carried out on that weld within 3 days of the weld having been completed.

13.2.6.1 Method for original procedure

13.2.6.1.1 Alternative acceptance criteria purposes.

When the CTOD approach is used to derive alternative weld acceptance criteria for production welding, as indicated at the enquiry stage, CTOD testing in accordance with appendix H shall be carried out on the welding procedure approval test joint.

13.2.6.1.2 Alternative to Charpy testing. When CTOD testing is to be used for welding procedure approval purposes as an alternative to Charpy impact testing, the tests shall be carried out in accordance with appendix H at the minimum design temperature and the results shall be in accordance with the minimum values determined from figures 8 to 15 or as specified by the employer.

Group 1 test specimens shall be used as an alternative to weld metal Charpy tests and Group 2 test specimens shall be used instead of heat-affected zone Charpy tests.

Six CTOD test specimens, two each at locations at least 90° from each other, shall be taken in each case.

NOTE. When CTOD testing is used for welding procedure approval, table 9 is not precluded from being used for the acceptance criteria for production welds.

13.2.6.2 Method for repair procedure. When CTOD testing has been used to obtain the approval of the original welding procedure, or to obtain alternative weld acceptance criteria in accordance with appendix H, the following CTOD specimens shall be removed from each repair procedure test weld and tested at the minimum design temperature.

Group A. Three preferred geometry CTOD specimens with the notch positioned along the centreline of the repair weld.

Group B. Three preferred geometry CTOD specimens with the notch positioned such that the fusion boundary between the repair weld and the original weld intersects the notch tip at the mid-depth position of the repair weld (see figure 21).

Group C. Three preferred geometry CTOD specimens with the notch positioned such that the fusion boundary between the repair weld and the pipe material intersects the notch tip at the mid-depth position of the repair weld (see figure 21).

Criteria for acceptance or re-testing shall be as specified in 13.2.6.1 for the original welding procedure.'

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December 1987

Table 5. Test specimens for procedure approval test joints

In the column headed 'Transverse tensile', delete the first entry '0' and substitute 'see 13.2.1'.

Delete the heading 'Charpy impact' and all the values in the last column.

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Table 6. Hardness values

In the † footnote, delete 'Appendix C of BS 639 : 1976' and substitute 'BS 6693 : Part 2'.
In the ‡ footnote, delete '13.5.2' and substitute '13.2.4.2'.

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Table 7. Impact specimen sizes and values of impact energy

Delete the table and footnote and substitute the following new table and footnote.

Table 7. Impact specimen sizes, test temperatures and values of factor *F*

Pipe thickness	Charpy V-notch specimen size	Test temperature*	Value of <i>F</i> (see 13.2.5.1 (a)) used to determine:	
			Min. average value of impact energy	Min. individual value of impact energy
mm	mm	°C		
6.3 and over but less than 10	10 × 5	0	14	18
10 and over but less than 12.5	10 × 7.5	0	12	15
12.5 and over up to and including 16	10 × 10	0	10	12
Over 16 up to and including 20	10 × 10	-10	10	12
Over 20 up to and including 25	10 × 10	-20	10	12
Over 25	10 × 10	To be specified by the employer		

*These test temperatures are based on a minimum design temperature of 0 °C for joints in the as-welded condition; for a lower design temperature the relevant test temperature should be decreased by the same amount. For joints that are post-weld heat treated, the test temperature may be raised to the minimum design temperature for all thicknesses of pipe up to and including 25 mm.

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New clause 14.1

Insert a new clause 14.1 as follows:

'14.1 Non-destructive testing. All fillet welds shall be examined visually (see BS 5289) followed by either:

- (a) magnetic particle testing (see BS 6072); or
- (b) an alternative method or additional method agreed between the contracting parties (see 36.1).

NOTE. The agreement of the statutory authority may also be required.

The results from visual examination and non-destructive testing shall be assessed according to the appropriate acceptance criteria specified in clause 41.'

Delete the number and title of the existing clause 14.1 and substitute the following:

'14.2 Destructive testing

14.2.1 Test specimens. '

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Clause 14.2 Fracture test

Delete the clause number and title and substitute the following:

'14.2.2 Fracture test '

Renumber the existing subclauses 14.2.1 and 14.2.2 as 14.2.2.1 and 14.2.2.2, respectively.

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Clause 14.2.2.1 Requirements (as renumbered)

In line 1, delete '14.2.2' and substitute '14.2.2.2'.

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December 1987

Clause 14.3 Macro-examination

Delete the clause number and title and substitute the following:

'14.2.3 Macro-examination'

Renumber the existing subclauses **14.3.1** and **14.3.2** as **14.2.3.1** and **14.2.3.2**, respectively.

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Clause 14.2.3.1 Requirements (as renumbered)

In line 1, delete **'14.3.2'** and substitute **'14.2.3.2'**.

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December 1987

Clause 14.4 Hardness survey

Delete the clause number and title and substitute the following:

'14.2.4 Hardness survey'

Renumber the existing subclause **14.4.1** as **14.2.4.1**.

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Clause 14.2.4.1 Requirements (as renumbered)

In line 1, delete **'14.4.2'** and substitute **'14.2.4.2'**.

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Clause 14.4.2

Delete the existing clause number and substitute the following:

'14.2.4.2 Method.'

AMD 5810
December 1987

Clause 15.1 General

At the end of paragraph 2 insert the following.

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

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Clause 15.2.2 Positional welding

Delete the last two paragraphs.

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December 1987

Clause 15.4.3 Fillet welds in all positions

Delete the last two paragraphs and the note.

AMD 5810
December 1987

Clause 15.5 Changes affecting approval (essential variables)

At the end of the clause insert the following item:

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

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December 1987

Clause 16. Multiple approval for manual welding

Delete item (a) and re-letter the remaining paragraphs accordingly.

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Clause 19.2 Butt joints

In line 3, delete **'13.4'** and substitute **'13.2.3'**.

In line 2 of the note, delete **'13.4'** and substitute **'13.2.3'**.



Documents

Document Sharing Hub

AMD 5810
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Clause 25. Fusion faces

In line 5, delete 'bevel' and substitute 'fusion faces'.

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Clause 38.2.3

In line 2, delete '8 mm² to 10 mm²' and substitute '80 mm² to 100 mm²'.

In line 9, before 'hole', insert '1.5 mm'.

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December 1987

Table 9. Acceptance criteria for welds

For item (a) in column 2 in the second sentence of paragraph 1, delete 'weld' and substitute 'joint' and at the end of the sentence insert 'on each side'.

For item (j) in column 2, delete paragraph 1 and the associated footnote and substitute the following:

'Not to exceed a total area when projected radially through the weld of 2 % 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'.

Also for item (j) in column 2, in paragraph 2, line 1, delete '20 %' and substitute '25 %'.

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Clause 42.3 Re-welding

Delete the complete clause and substitute the following:

'42.3 Approvals. Repair welding procedures shall be approved when required by clause 11. The test weld to approve a partial penetration repair weld procedure shall be made into an excavation to a depth of at least half the pipe thickness centred on the toe of the original weld. One full penetration and one partial penetration repair test shall approve all repair procedures except for root sealing or single run repairs.

Welders shall be re-approved to use the repair procedure when required by 15.5.'

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New clause 42.4

Insert a new clause 42.4 as follows:

'42.4 Re-welding. Root sealing or single run repair deposits shall only be undertaken if approved by the employer.

NOTE 1. The approval of the statutory authority may also be required.

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.

NOTE 2. The approval of the statutory authority may also be required.

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.

NOTE 3. 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. Repairs should not be permitted to cause the stress applied to the weld under repair to exceed 80 % of the specified minimum yield strength of the pipe.

Full penetration repairs shall only be implemented under constant supervision. If repairs cannot be implemented within these limitations, or are not effected successfully, the weld shall be cut out.

Full records of all repairs shall be maintained.'

Clause H.4 Measurement of weldment fracture toughness for approval of welding procedures

Delete the complete clause, and substitute the following:

H.4 Measurement of weldment fracture toughness for approval of welding procedures

H.4.1 Number of test welds. When a welding procedure has been selected for approval, the required number of welds as agreed between the contracting parties shall be made for the purposes of testing. As well as the procedure approval test specified in section two, the tests specified in H.4.2 shall be carried out.

H.4.2 Fracture toughness (CTOD) tests (see BS 5762). CTOD specimens shall be prepared as detailed in (a) and (b) for each group or, for repair welds, in accordance with 13.2.6.2. Specimens shall be tested at the minimum design temperature that the pipeline will experience either during construction and laying, or in service.

NOTE 1. The purpose of these tests is to try to identify and measure the regions of poorest toughness within the weldment. If any region within the weld is suspected of being particularly susceptible to brittle fracture it is recommended that additional tests be conducted to ascertain its toughness.

(a) *Group 1: Weld metal.* Three preferred geometry CTOD specimens with the notch positioned along the centreline of the weld metal.

(b) *Group 2: Heat-affected zone.* Three sets of three preferred geometry CTOD specimens, each set located as shown schematically in figure 22. Thus, taking e as the pipe thickness, one set notched so that the line of the notch intersects the fusion boundary at the $e/4$ position; second set notched to intersect the fusion boundary at the $e/2$ position and the third set notched to intersect the fusion boundary at $3/4 e$ position.

The notch shall cross the fusion line at the intended location within a tolerance of ± 1.5 mm measured along the line of the notch. When the angle of bevel, as stated in the welding procedure, at the line of the CTOD specimen notch is less than 15° , the notch location shall be checked by means of sectioning and metallographic examination.

NOTE 2. For bevel angles of less than 5° , an alternative criterion of acceptability may be used by agreement with the employer, since the notch may not have crossed the fusion line although a substantial length of the line of the notch may be within the heat-affected zone. Acceptable notch locations may be those for which the line of the notch is both within the heat-affected zone and not further than 0.5 mm from the fusion boundary, for a distance of at least 1 mm either side of the intended sampling position.

H.4.3 Crack tip opening displacement (CTOD) testing considerations. All the CTOD tests shall be tested in displacement control and as described in BS 5762, at a laboratory approved by the employer. However, as BS 5762 does not take account of the specific problems encountered with testing welds or materials with curvature, such as found in pipes, the following shall also apply.

(a) The test specimens shall not be flattened.

(b) The pipe curvature shall **not** be machined from the specimen unless deemed necessary by the employer in order to carry out local compression prior to the fatigue pre-cracking of the specimens.