TECHNICAL SPECIFICATION

# PIPELINE FITTINGS
(AMENDMENTS/SUPPLEMENTS TO MSS SP-75)

DEP 31.40.21.30-Gen.

December 1995

**DESIGN AND ENGINEERING PRACTICE**

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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Shell International Oil Products B.V. (SIOP)
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## PART I INTRODUCTION

### 1.1 SCOPE

This new DEP specifies requirements and gives recommendations for fittings for use in oil and gas transmission pipelines in both non-sour and sour service.

This DEP is based on MSS SP-75, 1993 Edition and shall apply as a supplement to that document. Part II of this DEP gives amendments and supplements to sections of MSS SP-75 which are considered necessary to enhance pipeline integrity in accordance with Shell Group requirements. Part III gives minimum requirements for hydrogen induced cracking sensitivity tests and Part IV gives a summary of testing and inspection requirements.

All fittings specified to be in accordance with this DEP shall comply with the requirements of MSS SP-75, as amended and supplemented herein.

NOTE: Both MSS SP-75 and this DEP adopt sampling as a method to determine batch compliance. Nevertheless, **all** fittings supplied shall comply with **all** requirements of this specification.

### 1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is primarily intended for use in oil and/or gas transmission pipelines and related facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

### 1.3 DEFINITIONS

#### 1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

#### 1.3.2 Specific definitions

**Defect (in NDT)** - a discontinuity or group of discontinuities whose indication(s) do not meet specified acceptance criteria.

**Indication (in NDT)** - evidence of a discontinuity that requires interpretation to determine its significance.

**Minimum operating** - the minimum temperature to which the pipeline or section of

**temperature** pipeline may be exposed during normal operational activities, including start-up and shut-down operations and controlled blowdown, but excluding abnormal situations such as pipeline ruptures.

**Fitting bevel** - the total weld preparation machined on the end of a fitting.

**Heat** - a batch of steel prepared in one steel making operation, resulting in one chemical composition.

**Lot** - a set of identical fittings which have been produced from the same heat, have undergone the same heat treatment and, if applicable, have been welded in accordance with the same welding procedure.

**Pipeline** - a system of pipes and other components used for the transportation of fluids, between (but excluding) plants. A pipeline extends from pig trap to pig trap (including the pig traps) or, if no pig trap is fitted, to the first isolation valve within the plant boundaries or a more inward valve is so nominated.

**Plate** - the material for manufacturing a welded fitting before being formed into the shape of a fitting.

**Purchaser** - term used in MSS SP-75 which has same meaning as Principal.

## 1.4 ABBREVIATIONS

| | | |
|---|---|---|
| CE | - | carbon equivalent |
| DN | - | diameter nominal |
| FBH | - | flat bottomed hole |
| GMAW | - | gas metal-arc welding |
| HAZ | - | heat affected zone |
| HIC | - | hydrogen-induced cracking |
| MT | - | magnetic particle testing |
| NDT | - | non-destructive testing |
| OD | - | outside diameter |
| Pcm | - | material cracking parameter |
| RDH | - | radial drilled hole |
| RT | - | radiographic testing |
| SAW | - | submerged arc welding |
| SMAW | - | shielded metal arc welding |
| UT | - | ultrasonic testing |

## 1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (Part V).

## 1.6 GUIDANCE FOR USE

The amendments to MSS SP-75 given in Part II are directly related to equivalent sections in MSS SP-75. For clarity, the section and paragraph numbering of MSS SP-75 has been used as far as possible. Where sections in MSS SP-75 are referenced within this DEP, it shall mean those sections as amended by this DEP. Sections in MSS SP-75 that are not amended by this DEP shall remain valid as written.

## 1.7 INFORMATION TO BE SUPPLIED BY THE PRINCIPAL

There are a number of items within this DEP which require input from the Principal. Where these are mentioned within this DEP, they are identified by an annotation (A) in the left hand margin, indicating an action required by the Principal. The information which shall be

supplied by the Principal to the Manufacturer at the time of order includes:

1. The requirements for testing in the stress-relieved condition (Part II, Section 8.3 and Section 11.1)
2. Minimum design temperature (Part II, Section 11.3)
3. The requirements for pig transmission (Part II, Section 18.2)
4. Type of fitting, e.g. sour service or non-sour service
5. Field hydrotest pressure.

## PART II AMENDMENTS/SUPPLEMENTS TO MSS SP-75

SECTION 1 SCOPE

1.1 Replace this section with the following:

This specification covers factory made seamless and welded, carbon-manganese and high-strength low-alloy steel butt welding fittings for use in gas and oil pipelines.

Bends produced by induction bending are not covered by this specification. For induction bends reference should be made to DEP 31.40.20.33-Gen. Other fittings not covered by this DEP include insulating joints, end closures and flanges.

Higher grade fittings shall not be substituted for fittings ordered to a lower grade without the approval of the Principal, irrespective of strength level.

1.4 Delete this section.

## SECTION 2 PRESSURE RATING

2.1 Replace this section with the following:

Pressure rating for pipe fittings shall be calculated in accordance with the rules established in ANSI/ASME B31.3 and DEP 31.40.00.10-Gen. The pressure rating for the fitting shall be the lowest calculated rating.

2.3 Delete this section.

2.5 Replace this section with the following:

The design of fittings shall be established by the mathematical analyses contained in ASME VIII Division 1 or ANSI/ASME B31.3. The design of fittings for which these codes do not provide mathematical analyses shall be established by proof testing in accordance with Section 4.

The design calculations, and/or results of relevant proof testing, shall be submitted for approval to the Principal.

## SECTION 6 MATERIALS

6.1 Replace this section with the following:

The steel shall be made in a basic oxygen or electric arc furnace. It shall be fully killed with a grain size of ASTM 7 or finer, as defined in ASTM E 112.

For quenched and tempered fittings, this grain size requirement shall not apply.

## SECTION 7 CHEMICAL COMPOSITION

7.1 Replace this section with the following:

The Manufacturer shall propose a chemical composition for the fittings. This composition shall be contained in the manufacturing procedure specification and shall comply with the maximum allowable limits specified in Table 1 as amended below. The chemical composition shall be determined for every heat by product analysis.

Replace Table 1 with the following:

**Table 1 Chemical requirements for product analyses**

| Element | Maximum Permitted Alloy Content, wt% | | Notes |
|---|---|---|---|
| C | 0.18 | | |
| Mn | 1.60 | (1.30) | 1 |
| Si | 0.45 | | |
| P | 0.025 | (0.020) | 1 |
| S | 0.010 | (0.003) | 1 |
| V | 0.08 | | 2 |
| Nb | 0.05 | | 2 |
| Ti | 0.04 | | 2 |
| Cr | 0.20 | | 3 |
| Mo | 0.10 | | 3 |
| Ni | 0.35 | | 3 |
| Cu | 0.40 | | 3 |
| Al | 0.05 | | 4 |
| N | 0.012 | | 4 |
| B | 0.0005 | | |
| Ca | | (0.006) | 5 |
| CE | 0.45 | | 6 |
| Pcm | 0.23 | | 7 |

Notes:
1. Maximum levels for sour service fittings are given in brackets.
2. V+Nb+Ti shall not exceed 0.15%.
3. Cr+Mo+Ni+Cu shall not exceed 0.6%.
4. The total Al: N ratio shall not be less than 2 :1.
5. Calcium additions are not necessary if satisfactory HIC test performance is achieved.
6. CE = C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15.
7. Pcm = C + Si/30 + (Mn + Cu +Cr)/20 + Ni/60 + Mo/15 + V/10 + 5B.

7.2 Replace this section with the following:

For all grades, analysis for all elements in the Table shall be performed.

7.3 Amend this section as follows:

The carbon equivalent shall not exceed 0.45.

SECTION 8 TENSILE PROPERTIES

8.3 Replace this section with the following:

Tensile properties shall be determined from specimens removed from a fitting which has been subjected to all heat treatment operations. Where stress relieving of the material will be performed, e.g. after field welding, additional tensile testing of parent metal and
(A) weldments shall be performed on stress-relieved specimens. The Principal shall specify if this condition applies.

8.6 Replace this section with the following:

For welded fittings, weld tensile specimens shall be taken from the fitting as shown in Figures A to D. The specimen shall be taken transverse to the axis of the weld seam. For arc welded fittings, an all weld metal tensile test should also be performed. Tests shall be performed at the same frequency as for base material except that a change in welding procedure shall require an additional test. The tensile strength shall meet the minimum requirements of Table 2.

The weld reinforcements shall be removed before tensile testing.

## SECTION 9 HEAT TREATMENT

9.1 Replace this section with the following:

The heat treating process shall be performed in accordance with a documented procedure. The Manufacturer shall also establish and follow procedures for maintaining heat and/or lot identity. Details of heat treatment shall be agreed with the Principal prior to the start of production. A record shall be maintained of each heat treatment and shall be included in the Manufacturer's data report.

Fittings shall be supplied in either normalised, normalised and tempered or quenched and tempered condition.

9.1.1 Replace this section with the following:

Stress relieving shall be performed at a temperature between 560 °C to 600 °C. Fittings shall be held at the stress-relieving temperature for at least one hour per 25 mm of maximum thickness, but never less than one half hour. Cooling shall be in the furnace or in still air.

## SECTION 11 NOTCH TOUGHNESS TESTING

11.1 Replace this section with the following:

Charpy V-notch tests shall be performed in accordance with ASTM A 370.

(A) If stress relieving is required for field welds, Charpy testing is also required in the simulated stress-relieved condition. The Principal shall inform the Manufacturer of the need for testing in the stress-relieved condition.

Impact testing shall be carried out using 10 x 10, 10 x 7.5 or 10 x 5 mm cross-section specimens. The largest possible specimen shall be used. Where the nominal fitting dimensions are insufficient to extract a 10 x 5 mm specimen, impact testing is not required.

For fittings of DN 250 (10 inch) or less, impact test specimens shall be taken parallel to the axis of the fitting (i.e. longitudinal specimens shall be taken). For fittings greater than DN 250 (10 inch), impact test specimens shall be taken transverse to the axis of the fitting, except where the wall thickness prevents extraction of a 10 x 5 mm specimen, in which case longitudinal specimens shall be taken.

For weld centreline and HAZ impact tests, only transverse specimens shall be used.

One set of three specimens shall be taken from the mid-thickness location in the fitting wall at the following positions, see Figures A, B, C, D, E1 and E2:

Seamless fittings - Fitting body

Welded fittings
- Fitting body at 90 degrees to the weld
- Weld centreline
- Fusion line
- Fusion line + 2 mm
- Fusion line + 5 mm

11.2 Replace this section with the following:

Charpy tests shall be performed on each test fitting taken for tensile testing.

11.3 Replace this section with the following:

The impact test temperature shall be lower than or equal to that specified below.

| Nominal wall thickness, wt (mm) | Test temperature (°C) |
|---|---|
| $wt \leq 16.0$ | T |
| $16.0 < wt \leq 25$ | T-10 |
| $25 < wt \leq 32$ | T-20 |
| $wt > 32$ | T-30 |

(A) T is the minimum design temperature, which shall be specified by the Principal. If no minimum design temperature is indicated, testing shall be performed at 0 °C.

The minimum absorbed energy requirements for full size (10 x 10 mm) specimens taken transverse to the fitting axis are given below.

| Grade | Minimum average value (J) | Minimum individual value (J) |
|---|---|---|
| WPHY42 | 27 | 22 |
| WPHY46 | 32 | 24 |
| WPHY52 | 36 | 27 |
| WPHY56 | 39 | 29 |
| WPHY60 | 41 | 31 |
| WPHY65 | 45 | 34 |
| WPHY70 | 48 | 36 |

For other specimen sizes and orientations, the values above shall be multiplied by the following factors:

| Size (mm) | Orientation | Factor |
|---|---|---|
| 10 x 10 | Longitudinal | 1.5 |
| 10 x 7.5 | Transverse | 0.75 |
| 10 x 7.5 | Longitudinal | 1.125 |
| 10 x 5 | Transverse | 0.5 |
| 10 x 5 | Longitudinal | 0.75 |

The shear area at the fracture surface of the test specimens shall be recorded. Each sample shall exhibit not less than 50% fibrous shear.

11.4 Delete this section.

Add new section:

## SECTION 11A HARDNESS TESTING

### 11A.1 REQUIREMENTS

For all types of fittings, base metal hardness tests shall be carried out on fittings in their final condition. Testing shall be performed in accordance with ASTM E 92 at 5 random locations of one fitting per size per heat.

For welded fittings, a series of Vickers hardness tests (HV10) shall also be made on a cross-section removed from the test fitting. These series of readings shall extend from unaffected base metal on one side across the weld to unaffected base metal on the other side. Three traverses shall be made, one 2 mm from the outer edge, the second across the centre and the third 2 mm from the inner edge. The spacing between the hardness impressions shall be 0.75 mm. The location of the hardness impressions for SAW fittings is shown in Figure F. The hardness impressions nearest the fusion line shall be within 0.5 mm of the fusion line.

### 11A.2 ACCEPTANCE CRITERIA

No hardness measurement shall exceed 248 HV10 for sour service fittings and 325 HV10 for non-sour service fittings.

## SECTION 13 TOLERANCES OF WELDING FITTINGS

13.1 Add to this section the following:

Tolerances for fittings DN 350 (14 inch) and smaller shall comply with ANSI/ASME B16.9, Table 1.

For a length of 100 mm from each fitting end, the average internal diameter shall not deviate from the nominal internal diameter by more than ± 1.5 mm, or by that permitted by ANSI/ASME B16.9 Table 1, whichever is the more stringent.

The ends of each fitting shall be tested for out-of-roundness using an internal ring gauge with a diameter of 5 mm less than the nominal internal diameter. The gauge shall pass freely into each end of the fitting when held normal to the fitting axis.

For bends the internal diameter shall be verified by passing a double gauge plate through each bend. The gauge shall have two parallel 6 mm thick aluminium plates, each a minimum of 97% of the nominal pipe ID, separated by a distance of 100 mm.

13.3 WELDING ENDS

Add to this section:

The entire end bevel shall be machined and root faces shall not be brought into tolerance by filing or grinding.

## SECTION 14 MANUFACTURE

14.1 Replace this section with the following:

Fittings should be made by forging, pressing, piercing, rolling, extruding, welding, or a combination of these processes. The forming steps in any of these processes shall be performed at a temperature in the austenitising range. The forming procedure shall be applied so that it will not produce injurious defects in the fittings.

14.4.1 Add to this section:

In addition to the mechanical tests specified in ASME IX and API 1104, Charpy impact tests and hardness tests shall be performed on the qualification test welds. Acceptance criteria for all tests shall be as given in Sections 8 and 11.

14.4.5 Add to this section:

Repair welding shall be executed using procedures qualified in accordance with the requirements of Section 14.4.1.

The repaired area shall be non-destructively tested by RT, manual UT and MT.

14.4.6 Replace this section with the following:

Fillet welds are not permitted.

14.5.2 Add to this section:

Imperfections of the following types exceeding the specified criteria shall be considered injurious defects:

a. Cold formed dents

All cold formed dents with a sharp bottom gouge and all sharp gouges (without dents) deeper than 1.0 mm shall be considered defects requiring rectification or rejection.

b. Offset of plate edges

The radial offset of plate edges (misalignment) for welded fittings with a nominal wall thickness of 12 mm or less shall be no more than 2 mm. For fittings with a nominal wall thickness greater than 12 mm, the maximum allowable radial offset shall be 12.5% wall thickness or 3 mm, whichever is smaller.

c. Height of weld reinforcement

The height of the weld bead shall not extend above the prolongation of the original surface of the fitting by more than 4 mm for fittings with a wall thickness less than 12.5 mm and 5 mm for fittings with wall thickness greater than or equal to 12.5 mm. The height of the weld reinforcement shall not come below a prolongation of the surface of the fitting.

d. Hard spots

For sour service fittings, any hard spot having a hardness greater than or equal to 248 HV10 shall be cause for rejection.

e. Arc strikes

Arc strikes may be removed by grinding provided the remaining wall thickness is within the specified tolerances. The ground area shall be merged smoothly into the original contour of the fitting by grinding.

f. Undercuts

An undercut shall be repaired when it exceeds any of the criteria given below:

- maximum depth of 1 mm and not exceeding 12.5% of the wall thickness with a maximum length of half the wall thickness, and not more than two such undercuts in any 300 mm of weld length.
- maximum depth of 0.5 mm, any length.

Repair shall be by grinding provided the remaining wall thickness remains within the specified tolerances.

14.5.3 Replace this section with the following:

Surface defects less than 6½ % of the nominal wall thickness in depth may be repaired by grinding.

In all cases where grinding repairs are made as a result of imperfections being disclosed by NDT, the part of the fitting containing such repairs shall be subjected to additional NDT using the same technique, and MT, after the grinding operation.

Repair of base material by welding is not permitted.

## SECTION 15 NON-DESTRUCTIVE INSPECTION

Add new section:

All personnel performing NDT activities shall be qualified in the technique applied, in accordance with ISO 9712 or equivalent.

A level II inspector is required for UT weld inspection and calibration of UT systems. A level III inspector is required for supervision of UT personnel and procedures. A level I inspector is acceptable for all other NDT methods. A level II inspector is acceptable for supervision of all other NDT methods.

All NDT shall be performed in accordance with written procedures. These procedures shall have the prior approval of the Principal.

NDT for acceptance of the fitting (final inspection) shall take place after all heat treating operations and, for a welded fitting, after hydrostatic testing of the fitting. It may, however, take place before cropping, bevelling and end sizing.

### 15.1 RADIOGRAPHIC INSPECTION

Add to this section:

For welds in fittings with a thickness greater than 20 mm, radiographic weld inspection shall be replaced by ultrasonic inspection.

Add the following sections:

#### 15.1.1 Radiographic technique

For acceptance of the radiographic films, the technique used shall result in a sensitivity better than 2% of the thickness of the weld metal and a relative film density of 2 to 3.5 in the weld metal.

The Manufacturer shall record on a review form, accompanying the radiograph, the interpretation of each radiograph and disposition of the fitting inspected.

#### 15.1.2 Reference standards

The penetrameter used shall be of the wire type in accordance with ISO 1027. The selection of penetrameter wire diameters shall be based on a sensitivity of 2% of weld metal thickness.

### 15.2 Replace this section with the following:

#### 15.2.1 Ultrasonic inspection

Fittings for sour service only shall be inspected for laminations, using ultrasonic examination. Ultrasonic lamination testing of each fitting body shall be performed using a helical pattern with at least 25% scanning coverage of the fitting surface.

Plate for welded fittings may be tested before forming using an oscillating scanning pattern. The scanning coverage using this technique shall be at least 12.5%. Alternatively, the scanning shall be executed along straight, evenly distributed parallel lines with a scanning coverage of at least 25%.

In addition, the longitudinal edges of plate for sour service fittings shall be 100% ultrasonically tested, over a width of at least 25 mm from the trimmed plate edge. This may be performed either before or after fitting forming.

Welds in fittings with a thickness greater than 20 mm shall be inspected over their entire length, for both longitudinal and transverse defects, using ultrasonic examination in accordance with Sections 15.2.2 and 15.2.3.

15.2.2 UT reference standards

The reference standard shall contain notches (N5 or N10) or radially drilled holes (3.2 mm), and/or flat-bottomed holes.

The Manufacturer may use a type of reference reflector not specified above, provided he can demonstrate to the Principal that the examination is at least as sensitive as prescribed in this specification. In such cases, the Manufacturer shall obtain approval from the Principal.

The primary reference sensitivity level shall be adjusted on the following reference reflectors:

| Examination Type | Reflector Type |
|---|---|
| Lamination detection | FBH 6.3 mm |
| Surface defect detection | Notch N5 |
| Defect detection body and fitting ends | Notch N5 |
| Defect detection weld | RDH 3.2 mm |

For all reference reflectors except for RDH 3.2 mm, the acceptance limit signal shall be equal to the primary reference sensitivity level, i.e. equal to the height of the signal produced by the reference reflector. For the RDH 3.2 mm reference reflector, the acceptance limit signal shall be 10 dB below the primary reference sensitivity level.

Flat bottomed holes for lamination detection shall be drilled to the midwall position.

15.2.3 UT acceptance limits

For weld and fitting body examination, indications exceeding the acceptance limit signal are unacceptable.

For lamination detection in plate, fitting body and fitting ends, the acceptance limits shall be based on the lamination size and frequency and be in accordance with the classification of ISO 12094, as described below:

| Location | ISO 12094 Lamination Acceptance Levels |
|---|---|
| Plate body<br>Plate edges | Table 3. Class B1<br>Table 4. Class E1 |

Add new section:

15.3 MAGNETIC PARTICLE INSPECTION

After bevelling, the complete circumference of the weld bevel shall be tested by magnetic particle inspection in accordance with the requirements of ASTM E 709.

The bevelled surface shall be free from defects such as cracks, laps or laminations visible to the naked eye as revealed by the magnetic particle inspection procedure.

Add new section:

15.4 VISUAL INSPECTION

The full body and welds (if applicable) of every fitting shall be examined internally and externally for surface defects. For internal examination of fitting DN 600 (24 inch) and

larger, the inspector shall pass through the bore of the fitting. Illumination greater than 500 lux shall be provided to enable proper inspection. The internal and external surfaces of the fittings shall be free from all gouges, arc strikes, laps, undercuts or other detrimental defects.

## SECTION 16 INSPECTION

16.2 Replace this section with the following:

The Manufacturer shall furnish the Principal with a certificate of compliance including the requirements of Sections 7, 8, 9, 11 and 15. The certificate shall comply with ISO 10474 type 3.1.B.

## SECTION 17 MARKING

17.1 Replace this section with the following:

The Manufacturer shall mark each fitting with the information specified below. The markings shall be painted on the outside surface and shall be executed in white block capitals of minimum height 19 mm.

- Purchase order and item number
- Serial number of the fitting
- DEP 31.40.21.30-Gen. and the material grade
- Diameter of the run/branch
- Wall thickness
- Manufacturer's symbol
- The term "SOUR" (when sour service is specified).

Add new section:

## SECTION 18 SUPPLEMENTARY REQUIREMENTS

Supplementary requirement SR-6 shall apply.

Add new section:

## 18.2 SUPPLEMENTARY REQUIREMENTS FOR PIGGING

### 18.2.1 General

(A) The Principal will inform the Manufacturer whether the pipeline will be pigged. In this case, pipeline fittings shall be designed to allow the free passage in either direction of intelligent inspection tools and pigs and/or spheres.

The Principal will specify the internal bore for fittings. Maximum and minimum internal deviation of the bore of a fitting, as internally measured by calliper, in relation to the specified bore shall be +/- 1.5 mm, unless otherwise agreed (see also section 13.1).

### 18.2.2 Design of barred tees

Barred tees shall have a configuration of bars as indicated in Figure G. The bars shall be made of mild steel and shall be welded with full penetration welds.

### 18.2.3 Design of sphere tees

The number and the area of the slots in the through-pipe of a sphere tee shall be such, that their total area equals the flow area of the branch outlet of the sphere tee.

The slots shall have rounded edges. The through-pipe in the sphere tee shall have small holes next to the slots to allow the sphere to be pushed past the slots if the flow is taken off through the bypass.

The thickness of the through-pipe shall not be less than that of the matching line pipe.

(A) Sphere tees shall be equipped with a 50 mm (two inch) diameter drainage point. The position of the drainage point shall be specified by the Principal.

The actual length of the sphere tee shall be advised by the supplier in the bid.

SECTION 19 MANUFACTURING PROCEDURE AND WELDING PROCEDURES

The Manufacturer shall produce a manufacturing procedure specification which shall be submitted for the Principal's approval at least two weeks prior to the start of production. The manufacturing procedure specification shall include the following as a minimum:

**Steel supply**

- Steelmaker
- Chemical composition:
  (a) Target chemistry;
  (b) Ranges for deliberately added elements;
  (c) Maxima for other elements specified in (Section 7.1).

**Fitting manufacture**

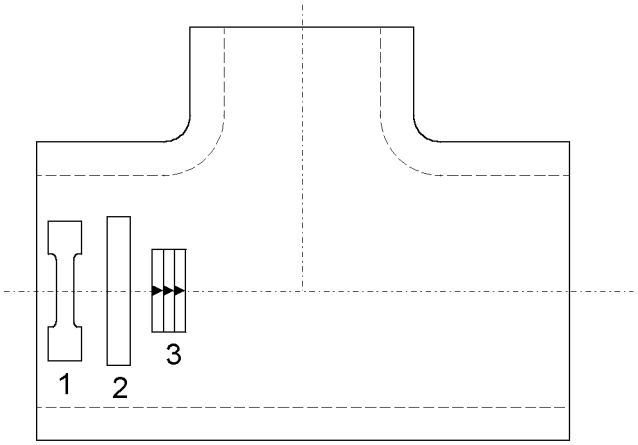
- Forming procedure
- Seam welding procedure for welded fittings
- Heat treatment procedure
- Hydrostatic test procedure
- NDT procedures.

Add new section:

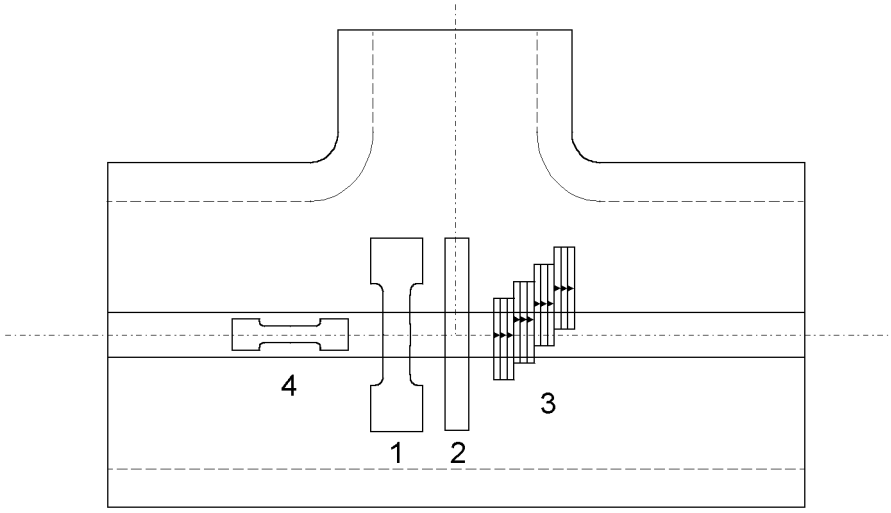
## SECTION 20 QUALITY SYSTEM

The Manufacturer shall establish and maintain a quality assurance system in accordance with ISO 9001, or an equivalent approved by the Principal.

**FIGURE A ORIENTATION OF TEST SPECIMENS TAKEN FROM EXTRUDED TEES**




## a) base metal




## b) weld seam

H76519/1P

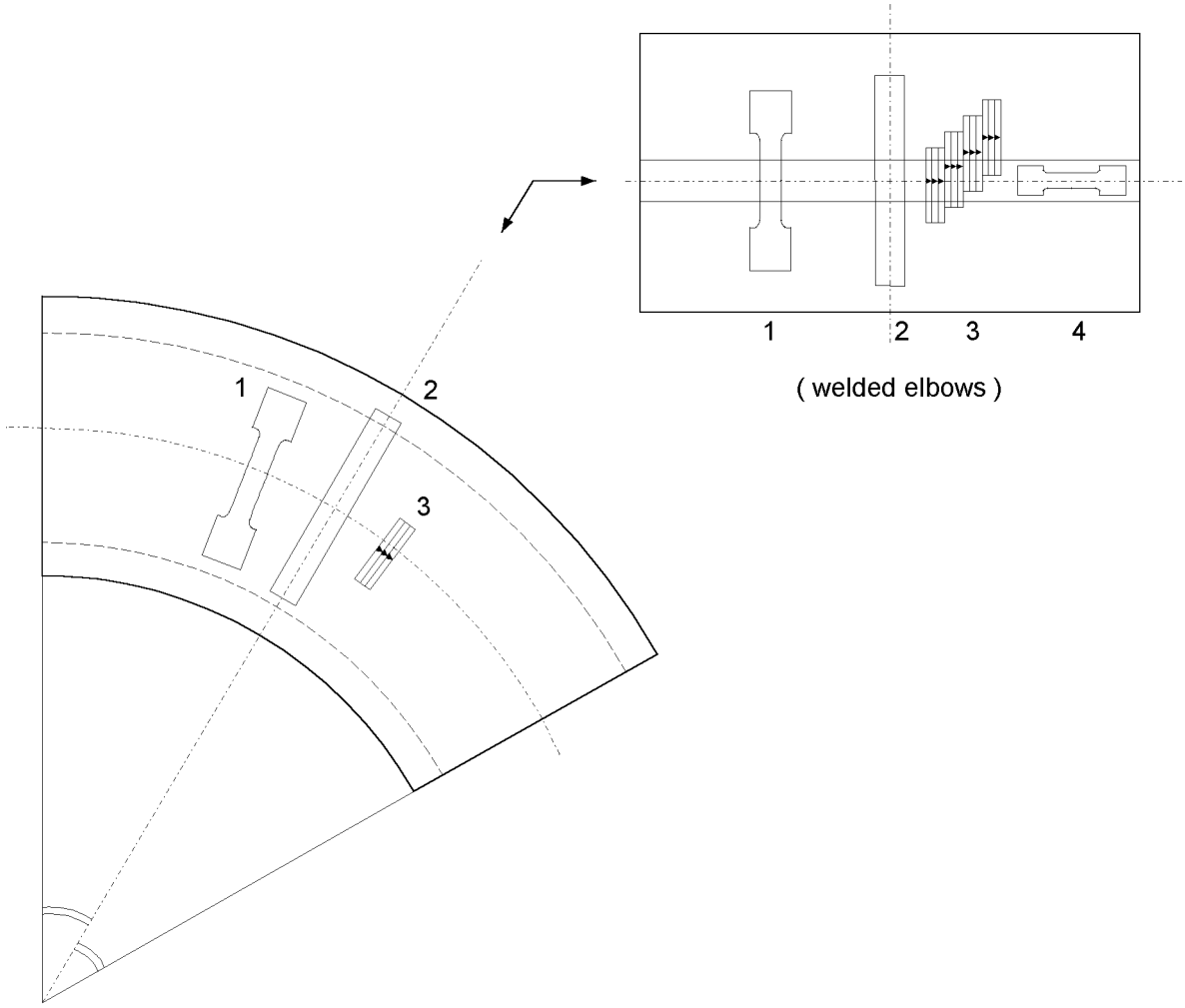
1 = transverse tensile test specimen

2 = macro / hardness specimen

3 = impact specimens ( notch perpendicular to the plate surface at mid thickness )

4 = all weld metal tensile test specimen ( not required if electric - welded pipe is used)

**FIGURE B ORIENTATION OF TEST SPECIMENS TAKEN FROM BENDS**




1 = transverse tensile test specimen

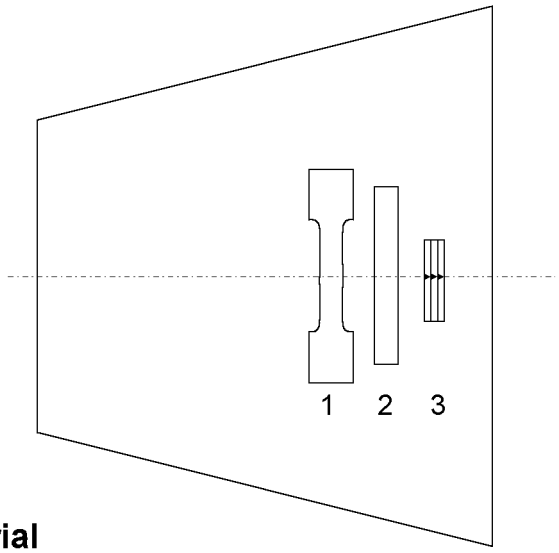
2 = macro hardness specimen

3 = impact specimens (notch perpendicular to the plate surface at mid thickness)

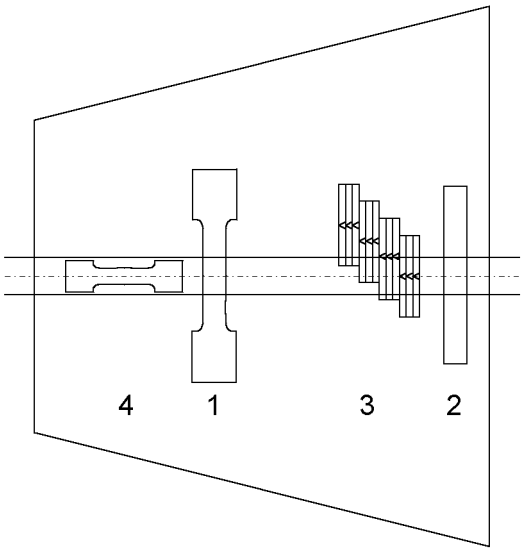
4 = all weld metal tensile test specimen

H76519/2P

**FIGURE C ORIENTATION OF TEST SPECIMENS TAKEN FROM REDUCERS**




**a) base material**




**b) weld seam**

H76519/3P

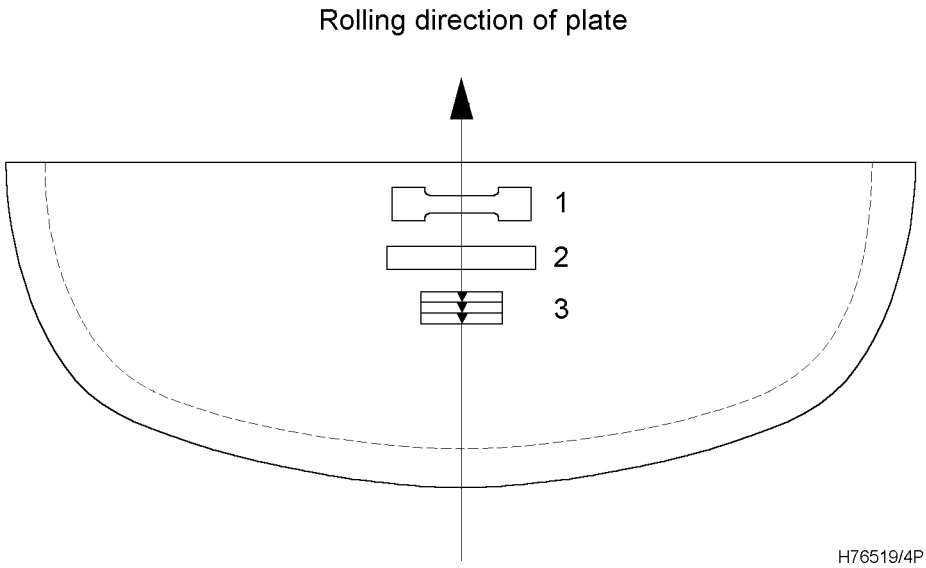
1 = transverse tensile test specimen

2 = macro / hardness specimen

3 = impact specimens (notch perpendicular to the plate surface at mid thickness)

4 = all weld metal tensile test specimen

**FIGURE D ORIENTATION OF TEST SPECIMENS TAKEN FROM CAPS**




1 = tranverse tensile test specimen

2 = micro / hardness specimen

3 = impact specimens ( notch perpendicular to the plate surface at mid thickness )

**FIGURE E1 LOCATION OF CHARPY V NOTCH SPECIMENS IN FITTING WELDS**

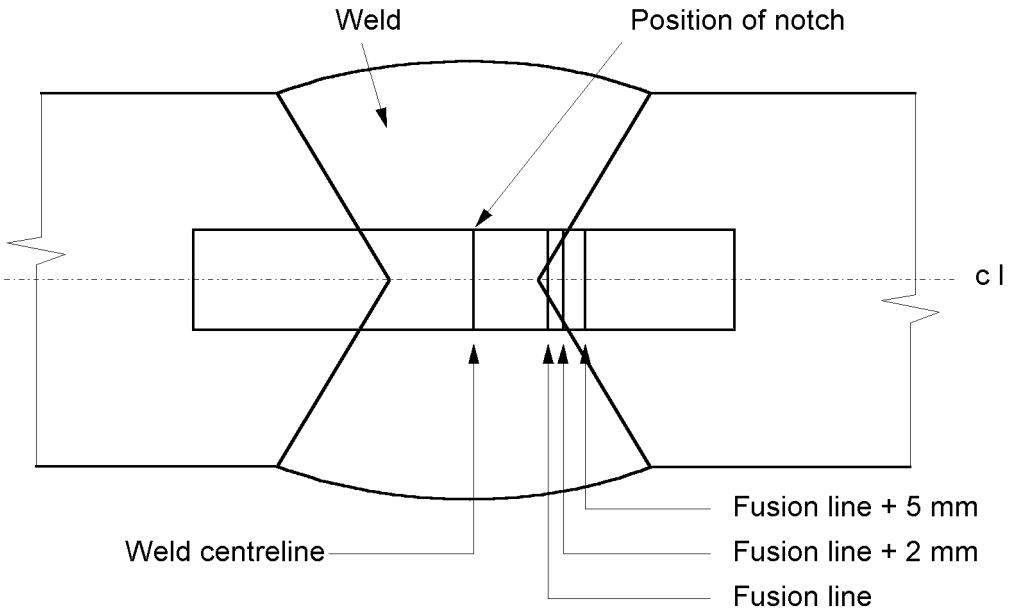



**FIGURE E2 DETAIL OF FUSION LINE CHARPY NOTCH LOCATION**

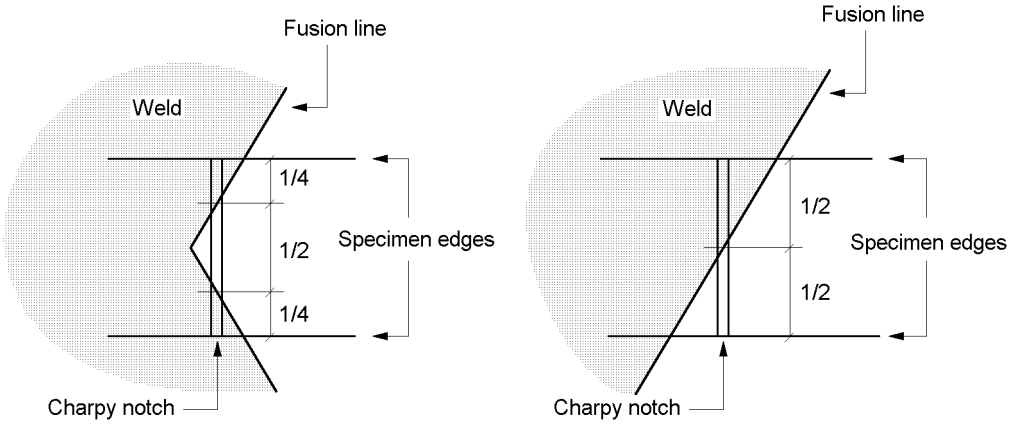
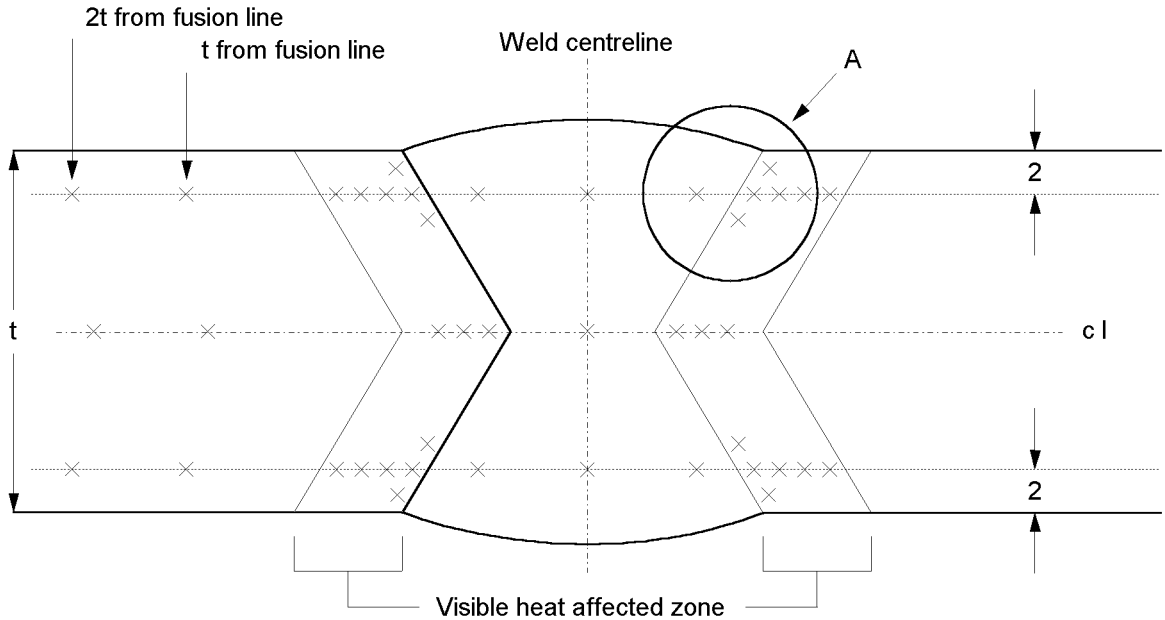
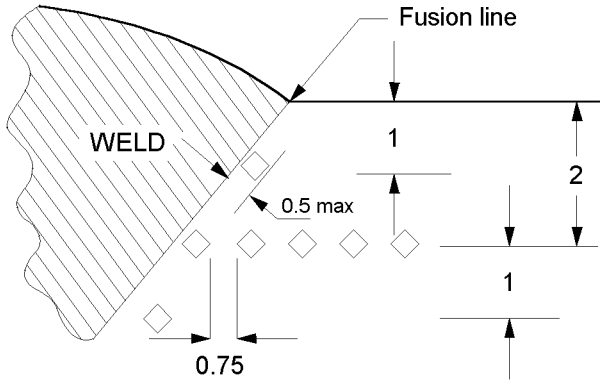


**FIGURE F WELD HARDNESS SURVEY**

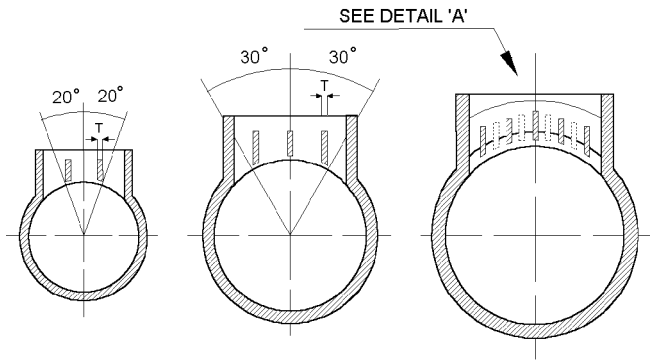


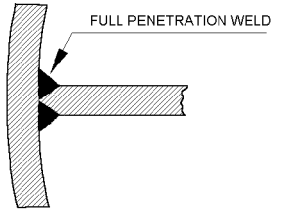

Enlargement of area A




H74753/13P (all dimensions in millimeters)

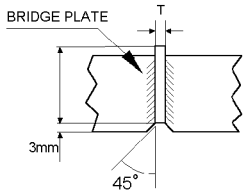
## FIGURE G DESIGN OF BARRED TEES



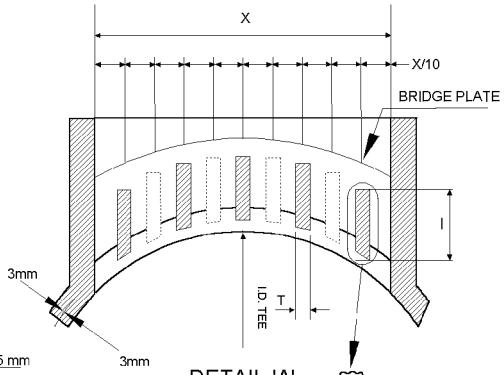




TYPICAL WELD DETAIL

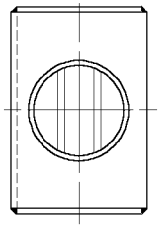
| BARRED TEES | | | |
|---|---|---|---|
| NOM. BRANCH SIZE | No. OF BARS | T | l |
| 4" | 2 | 6 | 25 |
| 6" | 2 | 9 | 50 |
| 8" | 2 | 9 | 50 |
| 10" | 3 | 12 | 50 |
| 12" | 3 | 12 | 50 |
| 14" | 9 | 12 | 50 |
| 16" | 9 | 12 | 75 |
| 18" | 9 | 12 | 75 |
| 20" | 9 | 12 | 75 |
| 22" | 9 | 19 | 100 |
| 24" | 9 | 19 | 100 |
| 26" | 11 | 25 | 100 |
| 28" | 11 | 25 | 100 |
| 30" | 13 | 25 | 100 |
| 32" | 13 | 25 | 100 |
| 36" | 13 | 25 | 100 |



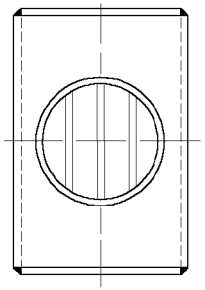

SECTION - 'BB'



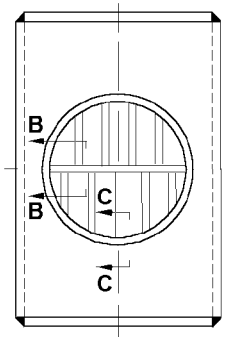

DETAIL 'A'



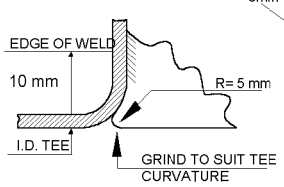
BRANCH SIZE 4", 6" & 8"



BRANCH SIZE 10" & 12"




BRANCH SIZE 14" TO 36" (typ)




SECTION - 'CC'

H77369/01P

Note: This drawing is not intended to be a complete procurement specification

## PART III HYDROGEN-INDUCED CRACKING SENSITIVITY TESTS

### 3.1 SELECTION OF SAMPLES

For sour service fittings made from plate or pipe, the Manufacturer shall perform HIC sensitivity tests. HIC testing is not required for forged fittings. One fitting from the first heat of steel plus one fitting out of every subsequent ten heats shall be tested. The fittings for testing shall be selected from the heats exhibiting the greatest Sulphur contents. The test shall be witnessed by the Principal and the results submitted to the Principal. If a sample fails to pass the test, the situation shall be reviewed by the Principal, to decide on further testing to distinguish heats which are acceptable.

## 3.2 QUALIFICATION OF TEST METHOD

Before commencement of manufacture, the Manufacturer shall provide the Principal with a detailed procedure for the testing, metallographic preparation and evaluation of HIC specimens. The Manufacturer shall qualify his test method using samples from a steel of known crack sensitivity. All tests shall be witnessed by the Principal.

## 3.3 SAMPLING

### 3.3.1 Removal of test coupons

**Welded Fitting**

Two coupons, each to be sectioned into three specimens, shall be selected and tested for each fitting selected.

Coupon 1 - cut from the fitting opposite the weld seam and in a direction parallel to the rolling direction, see Figure H.

Coupon 2 - cut from the fitting transverse to the weld, see Figure I.

### 3.3.2 Specimen preparation

Three adjacent specimens shall be cut from each coupon with dimensions as shown in Figures H and I. The specimens shall be rough ground on a belt grinder or by surface grinding, followed by final grinding to a 320 grit finish, using silicon carbide papers. They shall then be degreased in acetone. The effectiveness of degreasing shall be demonstrated by using the atomizer test of ASTM F 21. Thereafter, extreme care shall be taken not to contaminate the coupons. They should only be handled with tongs or clean gloves. One set of specimens from both the seam weld and base fitting material shall be tested, without applied stress, in the test solution. Tests shall be carried out with specimens that are not coated in any way before exposure in the test environment.

3.4 TEST SOLUTION

The test shall be performed in the NACE TM0177 test solution, i.e. 0.5% acetic acid + 5% NaCl + $H_2S$. The testing shall be performed in glass vessels.

The solution shall be deaerated by bubbling nitrogen through it at a rate of 100 ml/l/min for one hour. The specimens shall be immersed in the solution with the face of 100 mm x 20 mm in the vertical position and the lower face raised from the cell bottom on bars of solid PTFE or glass. When stacked, the specimens shall also be separated by similar bars, see Figure J.

Nitrogen bubbling shall be continued for a further one hour after which the solution shall be saturated by bubbling $H_2S$ at the rate of 2 to 5 litres/min for one hour through an open-ended tube with a 5 mm internal diameter. Upon reaching saturation, the $H_2S$ flow rate may be reduced to 100 ml/min, for a 10 litre solution or pro rata, and maintained at this rate for the test period. The $H_2S$ purity shall be at least 99.5 vol%.

A small positive pressure of $H_2S$ should be maintained in the test cell by the use of an outlet trap to prevent oxygen contamination from the air. If at any time during the test, a white haze clouds the solution, the test shall be stopped and repeated after preparation of new specimens.

The test conditions shall be as follows:

| | | |
|---|---|---|
| Temperature | | (25 ± 3) °C |
| $H_2S$ concentration | | 2300-3500 ml/$m^3$ |
| pH | initial | 2.9 to 3.3 |
| | final | 3.5 to 4.0 |
| Test period | | 96 hours |

The pH of the solution shall be measured at the beginning and the end of the test and the $H_2S$ concentration in the solution determined at the end by iodometric titration.

## 3.5 EVALUATION OF BLISTERING AND HYDROGEN-INDUCED CRACKING

### 3.5.1 Blistering

The tendency to blister shall be reported after visual examination. Photographs shall be taken of the two wide faces of each coupon to show any blistering. Where photography does not adequately show blisters a dimensioned sketch may be substituted.

### 3.5.2 Hydrogen-induced cracking

Specimens taken with their long axis (100 mm) parallel to the rolling direction shall be sectioned transversely at three points, as shown in Figure K. Specimens containing the weld, cut from a welded fitting (Figure I), shall be sectioned as shown in Figure L. The intention of the above sectioning procedure is to examine for cracks, in each case on a plane transverse to the rolling direction.

The sections shall be mounted in epoxy resin, or an equivalent, and polished. To avoid the possible obscuring of fine cracks, the metallographic preparation shall entail polishing to a finish of 1 µm or less. Cracking shall then be estimated by micrographic examination at magnifications of X30 and X100.

### 3.5.3 Evaluation

For each crack observed, the length and extent of stepwise propagation (Figure M) shall be measured. For each section containing cracks, one photograph shall be taken showing one of the complete transverse sections with examples of cracking.

HIC is evaluated in terms of crack length ratio (CLR), crack thickness ratio (CTR) and crack sensitivity ratio (CSR). All cracks are to be included in the CLR evaluation while only cracks assessed as stepwise cracks according to Figure M shall be included in the CTR and CSR evaluation.

These values shall be reported for each section examined and as the average of three sections per specimen. The results for each specimen, i.e. the average of the three sections examined, shall be used for evaluating HIC susceptibility. In this evaluation, cracks associated with surface blistering which have no part more than 1 mm from the specimen surface shall be disregarded.

### 3.5.4 Acceptance criteria

The following acceptance criteria shall apply:

| | |
|---|---|
| CLR | 15% maximum |
| CSR | 1.5% maximum |
| CTR | 5% maximum |

The maximum individual crack length on any section shall not exceed 5 mm.

If any specimen fails to meet the above acceptance criteria, the heat of steel represented by the test shall be rejected.

## 3.6 REPORTING

The following information shall be supplied in a report together with the test certificates.

a. Results of cracking evaluation indicating CLR, CTR and CSR for each section and also averaged over three sections, and pass/fail.

b. Photomicrographs of the specimens showing cracking, together with photomicrographs of adjacent material structures:

   i) Unetched, showing the type of inclusions in the steel

   ii) Etched, showing the parent material microstructure.

c. pH of $H_2S$-saturated solution at the beginning and at the end of the test, the $H_2S$ content and type of solution.

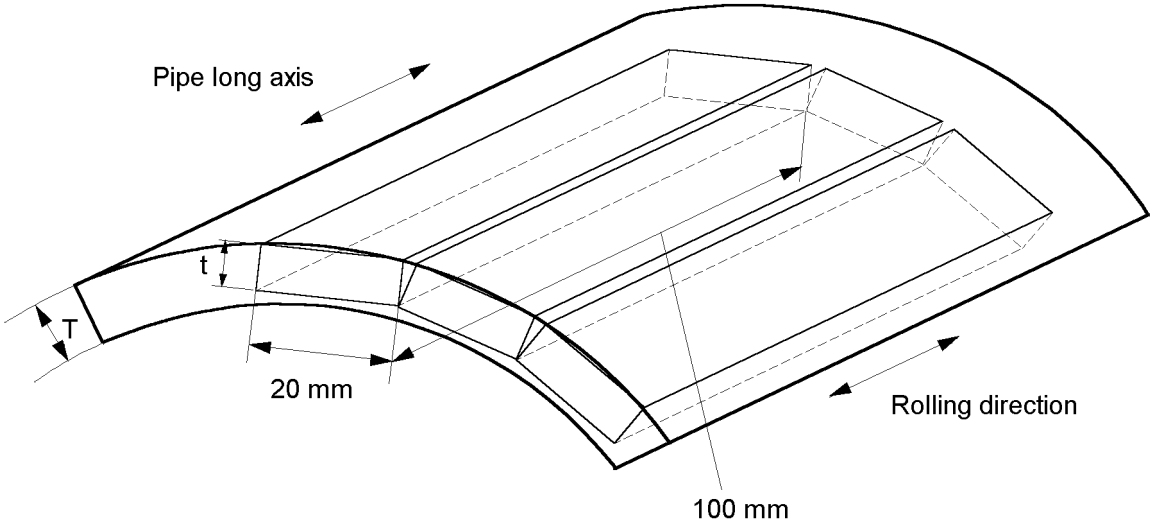
d. Photographs of specimens, showing any blisters, or alternatively dimensioned sketches.

e. Location and dimensions of specimens, and whether taken from fitting body or weld.

f. Full chemical analysis of material tested.

g. Mechanical properties of materials tested.

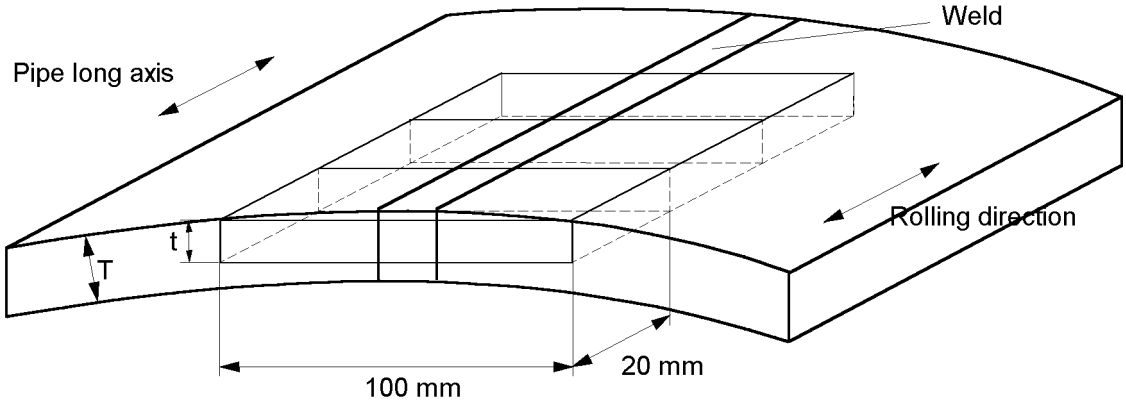
**FIGURE H COUPON FROM FITTING PARENT MATERIAL**




NOTE: t shall be as large as possible. If t cannot be greater than T minus 2.5 mm, coupons may be extracted from flattened specimens.

H74753/7P

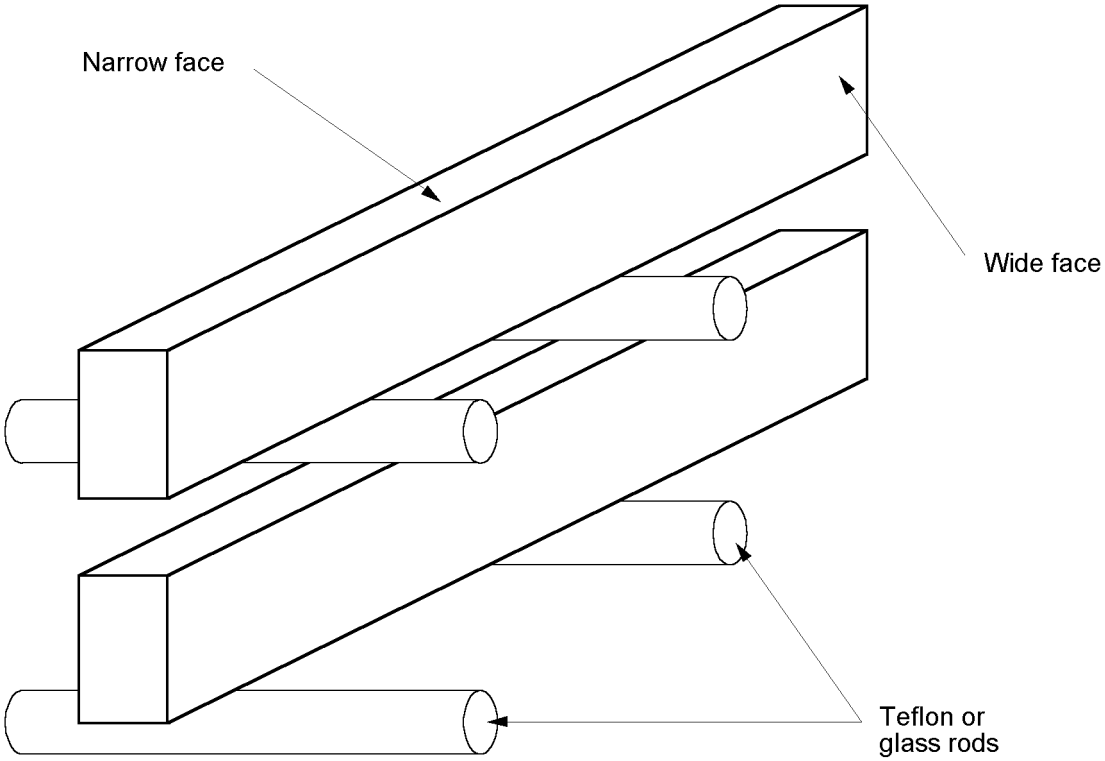
**FIGURE I COUPON FROM WELDED FITTING**




NOTE: t shall be as large as possible. If t cannot be greater than T minus 2.5 mm, coupons may be extracted from flattened specimens.

H74753/8P

**FIGURE J SPECIMEN ARRANGEMENT IN CELL**




H74753/9P

**FIGURE K SECTIONING OF SPECIMENS FROM FITTING PARENT MATERIAL**

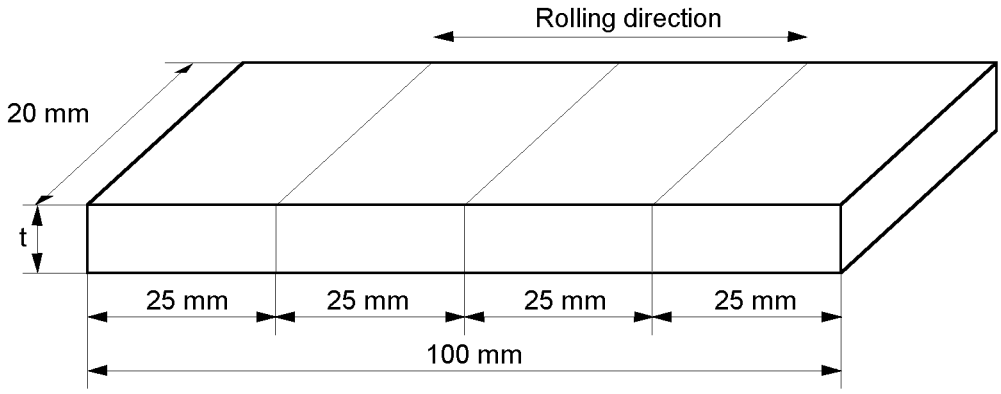
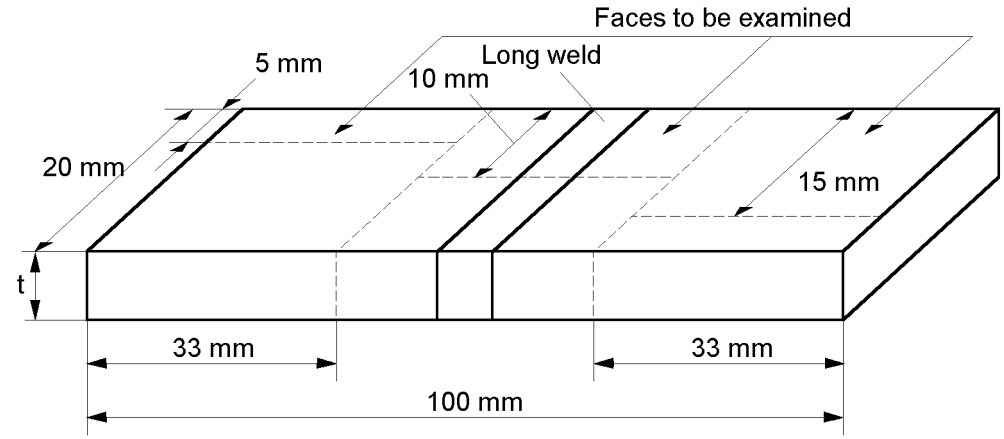
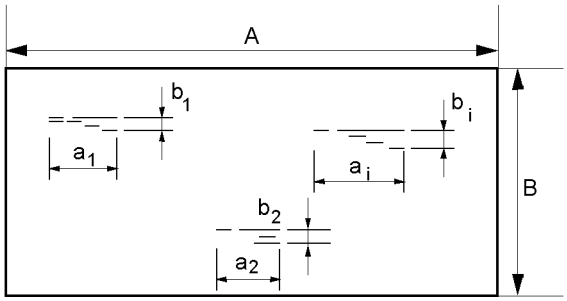



**FIGURE L SECTIONING OF SPECIMENS FROM WELD SEAM**



## FIGURE M EVALUATION OF HIC

Cracks are evaluated according to crack length ratio (CLR), crack thickness ratio (CTR) or crack sensitivity ratio (CSR) by measuring the total crack length, extent of stepwise cracks or stepwise crack area respectively.

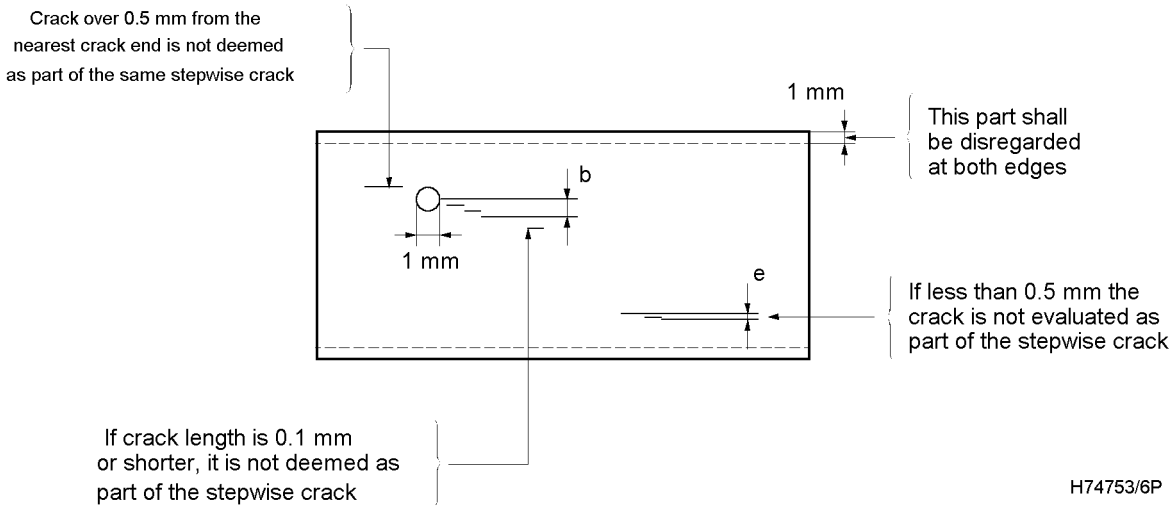



Length of stepwise crack = $\sum a_i$

Extent of stepwise crack = $\sum b_i$

CLR, CTR and CSR values can be calculated with the following equations.

$$CLR = \frac{\sum_{i=1}^{n} a_i}{A} \times 100\ (\%) \qquad CTR = \frac{\sum_{i=1}^{n} b_i}{B} \times 100\ (\%) \qquad CSR = \frac{\sum_{i=1}^{n} a_i \cdot b_i}{A.B} \times 100\ (\%)$$




Definition of stepwise crack

## PART IV SUMMARY OF TESTING AND INSPECTION

| Test/Inspection | Frequency | Remarks |
|---|---|---|
| VISUAL INSPECTION | | |
| - dimensions | all fittings | |
| - out-of-roundness at weld position | all welded fittings | |
| - fitting end squareness | 2 fittings per shift | |
| - out of planarity | 2 fittings per shift | |
| - surface defects | all fittings | external (plus internal ≥ DN 600) |
| RADIOGRAPHY | | |
| - weld seam | all welds | |
| - weld repair areas on seam weld | all weld repairs | |
| ULTRASONIC EXAMINATION | | |
| - fitting ends | all fittings | 25 mm of fitting ends |
| - welded fitting | | |
| - plate | all plates | 25 mm from edge of trimmed plate material |
| - weld seam | all fittings if greater than 20 mm thick | |
| - seamless fitting | all fittings | 25% of surface |
| MT | | |
| - bevel faces | all fittings | |
| PHYSICAL TESTS | | |
| - tensile test | one fitting per lot | |
| - weld tensile test | one fitting per lot or per change in welding procedure | |
| - all weld tensile test | as above | |
| - Charpy V-Notch | as required for tensile test | |
| - macro plus hardness | one fitting per lot or per change in welding procedure | |
| CHEMICAL COMPOSITION | | |
| - Ladle analysis | once per heat | |
| - Check analysis | twice per heat | |
| HYDROGEN-INDUCED CRACKING TEST | one fitting per ten heats | sour service only |

## PART V REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

### SHELL STANDARDS

| | |
|---|---|
| Index to DEPs and standard specifications | DEP 00.00.05.05-Gen. |
| Pipeline engineering | DEP 31.40.00.10-Gen. |
| Linepipe for use in oil and gas operations under non-sour conditions (Amendments/supplements to API Spec 5L) | DEP 31.40.20.30-Gen. |
| Linepipe for use in oil and gas operations under sour conditions (Amendments/supplements to API Spec 5L) | DEP 31.40.20.31-Gen. |
| Pipeline induction bends | DEP 31.40.20.33-Gen. |

### AMERICAN STANDARDS

| | |
|---|---|
| Welding of Pipelines and Related Facilities | API 1104 |

*Issued by:*
*American Petroleum Institute*
*Publications and Distribution Section*
*1220 L Street Northwest*
*Washington DC 20005*
*USA*

| | |
|---|---|
| Factory-made wrought steel buttwelding fittings | ANSI/ASME B16.9<br>1993 Edition |
| Chemical plant and petroleum refinery piping | ANSI/ASME B31.3 |
| ASME boiler and pressure vessel code<br>Section VIII: Rules for construction of pressure vessels | ASME VIII |
| Section IX: Welding and brazing qualifications | ASME IX |

*Issued by:*
*The American Society of Mechanical Engineers*
*345 East 47th Street*
*New York, NY 10017*
*USA*

| | |
|---|---|
| Standard test methods and definitions for mechanical testing of steel products | ASTM A 370 |
| Standard test method for Vickers hardness of metallic materials | ASTM E 92 |
| Standard test methods for determining average grain size | ASTM E 112 |
| Practice for magnetic particle examination | ASTM E 709 |
| Standard test method for hydrophobic surface films by the atomizer test | ASTM F 21 |

*Issued by:*
*American Society for Testing and Materials*
*1916 Race Street*

*Philadelphia, PA 19103*
*USA*

| | |
|---|---|
| Specification for High Test Wrought Butt Welding Fittings | MSS SP-75<br>1993 Edition |

*Issued by:*
*Manufacturers Standardization Society of*
*the Valve and Fittings Industry, Inc.*
*127 Park street, Northeast*
*Vienna, VA 22180*
*USA*

| | |
|---|---|
| Laboratory testing of metals for resistance to sulphide stress cracking in $H_2S$ environments | NACE TM0177 |

*Issued by:*
*National Association of Corrosion Engineers*
*1440 South Creek Drive*
*PO Box 218340*
*Houston, TX 77218-8340*
*USA*

**INTERNATIONAL STANDARDS**

| | |
|---|---|
| Radiographic image quality indicator for non-destructive testing | ISO 1027 |
| Quality systems - Model for quality assurance in design, development, production, installation and servicing | ISO 9001 |
| Non-destructive testing; qualification and certification of Personnel | ISO 9712 |
| Steel and steel products, inspection documents | ISO 10474 |
| Welded steel tubes for pressure purposes - ultrasonic testing for detection of laminar imperfections in strips/plates used in the manufacture of welded tubes | ISO 12094 |

*Issued by:*
*International Organization for Standardization*
*1, rue de Varembé*
*CH-1211 Geneve 20*
*Switzerland*
*Copies can also be obtained from national standards organizations*