TECHNICAL SPECIFICATION

SHOP AND FIELD FABRICATION OF PIPING

DEP 31.38.01.31-Gen.

December 1996
(DEP Circular 05/97 has been incorporated)

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for shop and field fabrication and testing of piping, which shall also comply with ANSI/ASME B31.3.

This DEP is a revision of an earlier DEP of the same number dated August 1988.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, 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 defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants and, where applicable, in exploration and production facilities and supply/marketing installations.

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, environment, 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, 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/Fabricator** is the party which manufactures or supplies equipment and services to perform the duties supplied 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 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

Hydrogen service	refers to all process conditions with a hydrogen partial pressure greater than 7 bar (abs).
Sour service	means "sour" service and "moderate/high severity wet H_2S" service, all of which are defined in DEP 31.38.01.11-Gen., Appendix 4.
Very toxic	substances are defined in DEP 31.22.10.32-Gen.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (5.)

2. PIPE FABRICATION

2.1 GENERAL

The basis for the fabrication of piping will normally be a 'Bill of Materials for Piping', which includes isometric drawings, material lists and (where necessary) additional information. For the content of the Bill of Materials, see DEP 31.38.01.13-Gen.

Contact between stainless steel parts and zinc or zinc-containing parts (e.g. galvanised shackles, clamps and rollers) shall be prevented in order to prevent possible liquid metal embrittlement in the event of a fire. If there is any doubt, the stainless steel shall be chemically cleaned before any further work is carried out.

2.2 PREPARATION

2.2.1 Cutting and bevelling

Cutting and bevelling of pipes may be done by either mechanical means, flame cutting, plasma cutting or water cutting. The following shall apply:

- For carbon steel, flame (or arc) cuts shall be reasonably smooth and all oxides shall be removed from the surface by grinding to bright metal.
- For low-alloy steel, after flame cutting approximately 2 mm of material shall be removed from the cut surface by grinding.
- For stainless steel, flame cutting shall not be used but plasma or water cutting may be used. The surface shall be ground to bright metal after plasma cutting.

Weld bevels for butt welds of pipes and fittings shall be in accordance with ANSI/ASME B16.25.

Shop-bevelling of field welds is not required if a make-up length (extra length for field cutting to size) is provided. In these cases bevels shall be prepared after cutting the relevant pipe spool to the required length.

Pipes for socket weld joints shall be cut square.

2.2.2 Assembly of piping components

For butt welding of all piping components (e.g. pipe ends, fittings and welding neck flanges) a uniform root gap shall be provided as specified in the relevant Welding Procedure Specification.

Unless otherwise stated on the isometric drawings, the bolt holes of all flanges shall straddle the centre lines of the pipe ends.

The minimum distance between the edges of two pressure-containing welds shall be 50 mm or twice the thickness of the thicker pressure part, whichever is the greater. This is required also for the distance between non-pressure attachment welds to a pressure-containing weld. Longitudinal welds in two adjacent pipes should be 180° apart, but in any case shall be separated by at least 50 mm or twice the wall thickness of the thicker pipe, whichever is the greater.

If the pipe contains a longitudinal weld, this weld shall not be located at the bottom of the pipe after installation; it should be located at least 45° from the bottom of the pipe.

2.3 BENDING

2.3.1 General

If economically attractive, bending of pipe spools may be considered as an alternative to using welded elbows. The application of bending and the extent of its use shall be agreed with the Principal at an early stage of a project, and in such cases the piping design shall be reviewed for the applied bend radii and adapted where necessary.

Bending radii shall be indicated on the isometric drawing. The bending radius, R_m, should be 5 x D_o (where D_o is the outside diameter of the pipe), but in any case shall not be less than 1.3 x D_o.

If the pipe contains a longitudinal weld, this weld should be located in the neutral zone of the bend. If the pipe will be installed horizontally, the longitudinal weld shall be located on the top of the pipe. If one spool is bent in various planes, the longitudinal weld shall be 45° from the top of the pipe.

Pipe bending shall be carried out in pipe bending machines or presses using formers. Tolerances for thinning, flattening and wrinkling are specified in (2.6.2).

The Manufacturer shall prepare a bending procedure which shall include:

- operating sequence;
- forming process and machinery used;
- production parameters, which shall at least cover:
  - width of heated band;
  - heating rate;
  - bending temperature range;
  - cooling rate, cooling method and coolant flow rate;
  - production bending speed;
  - method of temperature measurement and recording;
  - bend dimensions;
  - non-destructive examination procedures;
  - post forming;
  - fabrication procedure qualification ;
  - production control procedure.

Three types of bending processes are identified:

- Cold bending, which is defined as bending at a temperature well below the final heat treatment temperature of both ferritic and austenitic materials. Cold bending shall not be used for piping in sodium hydroxide service.

- Hot bending, which is defined as bending at a specified elevated temperature. Heat shall be applied uniformly before bending. Local heating by manually operated gas torches shall not be applied. Water cooling at any time during bending shall not be applied.

- High Frequency Induction Bending (HFIB), which is a hot bending process using machines in which the pipes are passed through an induction coil where, successively, a narrow band of pipe material is rapidly heated to the required bending temperature using the high frequency induction method. The adjacent pipe is kept cool by water and/or air jets, thus providing the necessary support for the heated area without the need for mandrels. It shall be ensured that the bending temperature is uniform over the complete circumference of the bend. An induction ring with a square profile should be used. An example of a Fabrication Procedure Qualification is attached as Appendix 1. HFIB can be economically attractive for carbon and stainless steel. For low alloy steel this method is generally attractive only for special applications (e.g. large diameters, large wall thicknesses) where welding elbows are not readily available. It should be noted that the logistics for HFIB differ from other pipe spool production methods and generally require a larger lay-down/stocking area because spools are in diameter/material batches rather than as required for installation in the plant.

Heat treatment shall be applied as specified in ANSI/ASME B31.3 and in sections 2.3.2, 2.3.3 and 2.3.4 below.

Bending of non-ferrous materials is outside the scope of this DEP.

2.3.2 Carbon steels, fine grain carbon steels, 0.3 Mo steels and 0.5 Mo steels

2.3.2.1 Cold bending

After cold bending no additional heat treatment is required if the following requirements are met:

- hardness < 248 HV10
- $R_m > 1.3 \times D_o$

If these requirements are not met, the following heat treatment shall be carried out:

- a normalising treatment for normalised steels;
- an austenising quench (oil, water) and temper treatment (Q+T) for quenched and tempered steels.

NOTE The above heat treatments may be replaced by a stress relief heat treatment at a temperature above the post weld heat treatment temperature) if it can be shown that there has been no deterioration of the mechanical and physical properties (e.g. grain growth).

2.3.2.2 Hot bending/HFIB

If normalised steels are subjected to hot bending between 780-980 °C no additional heat treatment is required. If normalised steels are subjected to the bending outside these temperature limits an additional normalising treatment shall be carried out. For HFIB the normalising heat treatment after bending need not be applied if the bend test defined in Appendix 1 shows a normalised structure with a grain size smaller than 6 (as defined in ASTM E112) and a hardness below 248 HV10.

For Q+T materials, a quench (oil, water) from the austenising temperature plus a temper heat treatment shall be carried out in accordance with the pipe material specification.

2.3.3 Chromium-molybdenum steel piping

2.3.3.1 Cold bending

After cold bending no additional heat treatment is required if the following requirements are met:

- hardness < 248 HV10
- $R_m > 1.3 \times D_o$

If these requirements are not met the following additional heat treatment shall be carried out:

- A stress relief treatment for normalised and Q+T steels if it can be shown that for similar material no deterioration of the mechanical and physical properties has taken place.
- If this cannot be shown then an austenising quench (air) and temper treatment for both normalised and Q+T steels shall be carried out. The tempering temperature shall be selected such that the specified mechanical values are met.

2.3.3.2 Hot bending/HFIB

If Q+T steels are subjected to hot bending at a temperature of 850-900 °C, an air quench from austenising temperature and a tempering treatment shall be carried out.

If normalised steels are subjected to hot bending at a temperature of 850-900 °C, a normalising heat treatment and cooling in still air shall be applied.

In all cases the specified mechanical values of the original material specification shall be met.

HFIB of ferritic materials with 5% Cr or more is outside the scope of this DEP.

2.3.4 Stainless steel piping

2.3.4.1 Cold bending

For non-corrosive and general refinery service, no additional heat treatment is required if the deformation is limited to below 20% for austenitic stainless steel or below 5% for duplex stainless steel. If the deformation exceeds these values a final heat-treatment shall be carried out in accordance with the original pipe material specification.

For all other services, solution annealing followed by a rapid water quench shall be carried out.

2.3.4.2 Hot bending/HFIB

For the non-stabilised types of austenitic stainless steel (e.g. AISI 304, AISI 316) hot bending shall be carried out in the temperature range of 1050-1100 °C (solution annealing) followed by a rapid water quench.

For the stabilised types of austenitic stainless steel (e.g AISI 316Ti, AISI 321, AISI 347) hot bending shall be carried out at the homogenising temperature (850-950 °C) followed by cooling in still air. Alternatively, a heat treatment at 1050-1150 °C, then lowering the temperature to 950-1000 °C, followed by cooling in still air, may be applied.

For duplex stainless steel, hot bending shall be carried out in the temperature range of 1050-1150 °C (solution annealing) followed by a rapid water quench.

For HFIB of austenitic and duplex stainless steel the complete pipe subjected to bending shall be heat treated as specified above for the various grades, in order to avoid the occurrence of sensitised areas.

2.3.5 Inspection

After bending, the bent items shall be visually inspected. There shall be no cracks or linear indications.

For HFIB, the inspection requirements are given in Appendix 2.

2.4 WELDING

In addition to the welding requirements of ANSI/ASME B31.3, the following shall apply:

The GTAW process shall be employed for pipes, branch fittings and flanges in sizes DN 50 and smaller.

For stainless steel piping without back welding of the internal side, the root pass shall be carried out by the GTAW process with an inert gas purge which shall be maintained until completion of the second pass.

Weld connections for welded valves and steam traps shall be in accordance with Appendix 3.

2.5 FINAL CORRECTIONS

Final corrections are modifications to the dimensions of a fabricated pipe spool in order to allow stress-free installation of this spool in the plant. For tolerances see (2.6).

The following methods of correction shall be used, in order of preference:

1. Adjustment of pipe support(s);
2. Adjustment of flange positions where free space is available in the bolt holes;
3. Local non-uniform heating or cooling;
4. Application of force with local heating;
5. Cutting and re-welding or the introduction of additional field welds or fit-up pieces.

The following restrictions apply to the heating, cooling and forcing of piping made from carbon steel, low alloy steel or austenitic stainless steel:

- Deformations shall not be greater than 5% in any area.
- **For carbon steel which does not require a PWHT**, the maximum temperature during alignment corrections shall be 600 °C. Temperature-indicating crayons or contact thermometers shall be used to measure the maximum temperature. If using temperature-indicating crayons a margin of 50 °C shall be taken to allow for measurement inaccuracy (i.e. the reading with the crayon shall not exceed 550 °C). Forcing may be applied if necessary. Cooling in still air shall be applied.
- **For carbon steel which requires a PWHT**, the maximum temperature during alignment corrections shall be the maximum PWHT temperature. Temperature-indicating crayons or contact thermometers shall be used to measure the maximum temperature. If using temperature-indicating crayons a margin of 50 °C shall be taken to allow for measurement inaccuracy (i.e. the reading with the crayon shall not exceed the maximum PWHT temperature minus 50 °C). Only heating with application of local force shall be used and no quenching shall be used. The area shall either be heated in full compliance with the PWHT procedure or the area which is heated (and corrected) shall be post weld heat treated.
- **For 0.5 Mo and Cr-Mo steels**, the maximum temperature during alignment corrections shall be the maximum PWHT temperature. Temperature-indicating crayons or contact thermometers shall be used to measure the maximum temperature. If using temperature-indicating crayons a margin of 50 °C shall be taken to allow for measurement inaccuracy (i.e. the reading with the crayon shall not exceed the maximum PWHT temperature minus 50 °C). Forcing may be applied if necessary. Cooling in still air shall be applied. Random hardness measurements shall be taken and the hardness shall not exceed 248 HV10.
- **For austenitic stainless steel**, the maximum temperature during alignment corrections shall be 650 °C. Temperature-indicating crayons or contact thermometers shall be used to measure the maximum temperature. If using temperature-indicating crayons a margin of 50 °C shall be taken to allow for measurement inaccuracy (i.e. the reading with the crayon shall not exceed 600 °C). The duration of heating shall be kept as short as possible and no forcing shall be applied.

2.6 TOLERANCES

The following dimensional tolerances shall apply:

2.6.1 Length

Length	less than 1.5 m	1.5 m and longer
distance of any two parallel or crossing centre lines	± 1.5 mm	± 3 mm
Centre to flange face		
Flange face to flange face		

2.6.2 Thinning, flattening and wrinkling of bends

The maximum decrease of wall thickness (thinning) shall not exceed 12.5% of the nominal wall thickness.

For flattening tolerances, see ANSI/ASME B31.3.

Wrinkling tolerances shall be as follows:

a) All wave shapes shall blend into the pipe surface in a gradual manner.
b) The maximum vertical height of any wave, measured from the average height of two adjoining crests to the valley, shall not exceed 3% of the nominal pipe size.
c) The minimum ratio of the distance between crests as compared to the height between crests and the valley in between shall be 12 to 1.

2.6.3 Flange face alignment

The maximum deviation measured in any direction shall not exceed 2.5 mm/m.

For combined service (e.g. level gauge connections), if branches are in the same plane and their flanges are also positioned in one plane, any deviation of the flange facings shall be in the same direction and shall not exceed 1 mm/m as measured from the combined branch plane.

Tolerances of flange connections between rotating equipment and associated piping shall be in accordance with DEP 31.29.00.10-Gen.

2.6.4 Position of bolt holes for flanged piping

The maximum deviation from the required theoretical bolt hole position, as measured along the bolt circle, shall be 1.5 mm.

2.6.5 Other dimensional tolerances

For other dimensional tolerances, see ANSI/ASME B16.9.

3. INSPECTION AND TESTING

3.1 GENERAL

All inspection and testing is the responsibility of the fabricator. All dimensions shall be checked to ensure that the fabrication meets the requirements of the isometric drawings within the specified tolerances. Inspection shall be carried out before any paint, coating or lining is applied. Pressure testing may be performed on fully painted piping spools (including welds) provided that:

- The welds consist of at least two layers (root and fill run) for stainless steels, and three layers for all other materials, in accordance with a Welding Procedure Specification qualified for the application.
- The test is not considered to be a sensitive leak test as specified in ANSI/ASME B31.3.
- The piping spool has been fully inspected (visual examination, non-destructive examination and positive material identification where specified) and released for pressure test.

Inspection of welds shall be carried out after final heat treatment in accordance with the inspection classes shown in Appendix 4. The methods to be employed for inspection shall be in accordance with ANSI/ASME B31.3. Acceptance criteria of welds shall be in accordance with ANSI/ASME B31.3. Progressive examination shall be carried out in accordance with ANSI/ASME B31.3.

3.2 HYDROSTATIC PRESSURE TEST

Test pressures shall be as stated on the isometric drawings, see (2.1). For pressure test procedures, see DEP 61.10.08.11-Gen.

3.3 HARDNESS REQUIREMENTS

Each welding procedure qualification shall include hardness tests (see 3.3.2).

Production welds shall be hardness tested as specified by ANSI/ASME B31.3, except that the production hardness tests shall be performed as specified in (3.3.2) and the maximum hardness (weld, HAZ and base metal) shall be 248 HV 10.

3.3.1 Hydrogen, hydrofluoric acid, and sour service

The hardness shall be measured on the welding procedure qualification test plates and on 10% of the production welds.

No part of the weld, HAZ or base metal shall exceed 248 HV 10.

NOTE See (1.3.2) for the definitions of hydrogen service and sour service

3.3.2 Hardness measurement method

Hardness measurements for welding procedure qualification shall be performed by the Vickers method, with hardness traverses in accordance with EN 1043-1. The series of readings shall extend from unaffected base material on one side, across the weld to unaffected base metal on the other side. Three traverses shall be made: one 2 mm below the outer surface, one 2 mm below the inner surface and one across the centre. The distance between measurements across the weld shall not exceed 2 mm.

Transverse weld hardness testing of production welds shall be carried out using a portable Vickers or Rockwell tester in accordance with ASTM E 110 or by another method capable of detecting a hard HAZ in a reliable and repeatable manner (e.g., Equotip, Microdur or other equivalent if approved by the Principal). Hardness tests shall be made on properly ground surfaces. For each set of hardness measurements required, the average of three measurements on the weld and on each HAZ shall be reported.

Hardness measurements shall be carried out after PWHT (if any).

4. PRESERVATION

Painting shall comply with DEP 30.48.00.31-Gen.

Pre-fabricated pipe spools shall be properly protected against corrosion and damage during storage and transport to site. Flange facings shall be provided with blanks or covers. Plain and bevelled pipe ends shall be provided with plastic covers.

5. 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 DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Installation of rotating equipment	DEP 31.29.00.10-Gen.
Compilation of Bill of Material for Piping Isometrics	DEP 31.38.01.13-Gen.
Field inspection prior to commissioning of mechanical equipment	DEP 61.10.08.11-Gen.

AMERICAN STANDARDS

Butt welding ends	ANSI/ASME B16.25
Factory made Wrought steel butt welding fittings	ANSI/ASME B16.9
Chemical Plant and Petroleum Refinery Piping	ANSI/ASME B31.3

Issued by:
American National Standards Institute, Inc.
1430 Broadway, New York
NY 10018, USA.

Standard test method for indentation hardness of metallic materials by portable hardness testers	ASTM E 110
Test methods for determining the average grain size	ASTM E 112
Practice for liquid penetrant examination	ASTM E 165
Practice for magnetic particle examination	ASTM E 709

Issued by:
American Society for Testing and Materials
1916 Race Street, Philadelphia
19103, USA.

EUROPEAN STANDARDS

Destructive tests on welds in metallic materials. Hardness testing. Hardness test on arc welded joints	EN 1043-1

Issued by:
Comité Européen de Normalisation
Secrétariat Central
Rue de Stassart 36
B-1050 Brussels
Belgium.

Copies can also be obtained from national standards organizations

APPENDIX 1 FABRICATION PROCEDURE QUALIFICATION FOR HIGH FREQUENCY INDUCTION BENDING (HFIB)

The Contractor and the laboratory in which the tests are to be performed shall be subject to approval by the Principal.

The Contractor shall submit a detailed sketch indicating the location of all test specimens for approval by the Principal.

For all materials, at least two test bends per material type shall be prepared, one with the smallest outside diameter and wall thickness and one with largest diameter and wall thickness.

For low-alloy steel, test bends as described above shall be prepared for each heat.

Qualification shall include all mechanical testing and all non-destructive examinations as specified by the material specification. In addition, for the smallest low-alloy steel qualification test bend, an extra micro-structure examination shall be carried out to verify the absence of micro-fissures.

There shall be no repair welding of test bends.

APPENDIX 2 INSPECTION AND TESTING OF PRODUCTION BENDS PRODUCED BY HIGH FREQUENCY INDUCTION BENDING (HFIB)

Each production bend shall be subjected to the following inspection and testing after bending and heat treatment:

- Dimensional checking for ovality, angle, etc. in accordance with ANSI/ASME B16.9.
- Visual inspection of the external surface including bevels and, where possible, the internal surface.
- The surface of bends shall be free of the defects listed below:
  - Any crack or suspected crack.
  - Any limitation, lap or dent.
  - Any excessive wrinkles as defined in (2.6.2).

For one bend of each production run (i.e. bending machine operating with same pipe size, wall thickness, material and all bending parameters within specified limits) the following tests shall be performed:

- Ultrasonic wall thickness measurement on the complete outer and inner radius of each bend shall be carried out to ensure that the wall thicknesses are within the required tolerances. Minimum and maximum values shall be recorded.
- Complete outside and (where accessible) inside magnetic particle examination to ASTM E709 for carbon steel and low alloy steel. There shall be no linear indications. The method used and the results shall be shown on the material certificate.
- Complete outside and (where accessible) inside liquid penetrant surface examination to ASTM E165 for stainless steel bends. There shall be no linear indications longer than 2 mm. The method used and the results shall be shown on the material certificate.
- Hardness tests shall be performed at 1/6, 1/2 and 5/6 of the bend angle on the outside surface with four measurements at each location, including the inner and outer radius and the neutral axis. Where possible, the same measurements shall also be taken on the inside surface of the bend.

  The hardness values shall be as specified in this DEP. The results shall be shown on the material certificate.

HYDROSTATIC TESTING

Hydrostatic pressure testing is not required prior to installation. The Contractor shall, however, certify that each delivered bend is capable of passing a hydrostatic test at the test pressure at which the original pipe has already been tested in the pipe mill. Hydrostatic testing of piping systems or spools including bends shall be carried out after installation at site.

APPENDIX 3 WELDING PROCEDURE FOR SOFT-SEATED WELDED VALVES

As well as complying with all applicable code requirements for quality and strength of the weld, it is necessary to avoid damage to soft seats and distortion of valve bodies by excessive heat input.

SOCKET WELD SMALL BORE VALVES:

The welding process to be used shall be shielded metal arc, metal inert gas or gas metal arc (which should be the lower heat input high deposition (dip transfer) processes). Gas welding shall not be used because of its excessive heat input.

During welding of the valve, the closure member shall be in the open position.

The pipe shall be correctly located and aligned in the valve socket with a clearance of approximately 1.6 mm between the end of the pipe and the bottom of the socket.

The first run of weld metal shall be deposited around the pipe. Additional runs, as required, shall be deposited ensuring that each run of weld metal is cleaned and any visible defects are removed before deposition of further weld metal. For detailed welding configuration see ANSI/ASME B31.3.

BUTT WELDED VALVES:

For butt welded valves the manufacturer's specification and limitations shall be followed.

APPENDIX 4 INSPECTION CLASSES FOR PIPING

Amended per Circular 05/97

Material	Service	ANSI rating class	Inspection levels in % (see legend) (A)		
			Radiography (B),(C),(D)	MT (E)	PT (E)
Carbon steel, including fine-grain carbon steel, 0.3 Mo steel and 0.5 Mo steel	Utilities	< 1500	10	10	
	Utilities	≥ 1500	100	10	
	Very Toxic service (1)	All ratings	100	100	
	Low temperature service (0 °C down to -50 °C)	All ratings	100	100	
	Hydrogen service (1)	All ratings	100	100	
	Other services	< 1500	10	10	
		≥ 1500	100	100	
Ferritic low alloy steel	All services	All ratings	100	100	
Stainless steels and non-ferrous alloys	Low temperature service (-50 down to -196 °C)	All ratings	100		100
	Hydrogen service (1)	All ratings	100		100
	Very Toxic service (1)	All ratings	100		100
	Other services	< 600	10		10
	Other services	≥ 600	100		100

NOTE (1) Hydrogen service and Very Toxic substances are defined in (1.3.2)

Legend

(A) The indicated percentage of welds to be inspected shall apply to all welders involved

(B) Ultrasonic examination may be applied instead of radiography if:
(i) the configuration precludes radiography
and (ii) pipe diameter >DN 100
and (iii) nominal wall thickness >10 mm

(C) Branch connections, including small nipples, shall be radiographed unless waived by the Principal

(D) Film quality requirements:
Fine grain film (Class II) for x-ray
Ultrafine grain film (Class I) for gamma ray

(E) MT = magnetic particle examination
PT = liquid penetrant examination