



GS 118-5

**THE FABRICATION, ASSEMBLY,
ERECTION AND INSPECTION OF
CARBON, CARBON MANGANESE AND
LOW ALLOY STEEL PIPEWORK TO
ASME B31.3**

August 1997

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING			
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Regional Applicability:		International	
SCOPE AND PURPOSE			
This document is a supplement to ASME B31.3. It provides additional detail to the base code and identifies BP's specific requirements for welding procedure qualification, welder skill, workmanship and integrity of process pipework utilising steels containing up to a nominal 13% chromium. The primary objective of this Guidance for Specification is to allow application of ASME B31.1 to BP plant pipework with confidence, fit-for -purpose and with enhanced safety.			
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Issued by:- Engineering Practices Group, BP International Limited, Research & Engineering Centre Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM Tel: +44 1932 76 4067 Fax: +44 1932 76 4077 Telex: 296041			

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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Guidance for Specification

This Guidance for specification clarifies and amplifies a number of ASME clauses on the basis of BP's fabrication experience worldwide.

Application

This Guidance for Specification is intended to guide the owner in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

It is a transparent supplement to [ASME B31.3](#) 1996 Edition, showing substitutions, qualifications and additions to the [ASME B31.3](#) text as necessary. As the titles and numbering of the BP text follow those of [ASME B31.3](#), gaps in the numbering of the BP document may occur. Where clauses are added, the [ASME B31.3](#) text numbering has been extended accordingly.

Text in italics is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options.

Throughout this document the term 'owner' is used to imply BP or their nominated representative. Any Specification subsequently prepared for the procurement of fabricated pipework should define the particular party responsible for the stated actions.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

This edition of BP Group GS 118-5 has been amended to make it compatible with BP Group [GS 118-7](#). The amendments are general in nature and do not consist of any major technical changes



Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

This document specifies general requirements supplementary to [ASME B31.3](#) - 1996 Edition, Chemical Plant and Petroleum Refinery Piping, Chapter V (Fabrication, Assembly and Erection) and Chapter VI (Inspection, Examination and Testing) and is applicable to both onshore and offshore piping systems fabricated in steels containing up to a nominal 13% chromium.

The welding of riser pipework and transmission pipelines is outside the scope of this Specification.

The titles and numbering within sections 3 and 4 of this BP Specification follow those of [ASME B31.3](#). As a result of this gaps in numbering may occur. All text is cross-referenced to [ASME B31.3](#) and qualifies, substitutes, modifies or adds to its requirements.

When additional text is to be read as an extension to the text of [ASME B31.3](#), the text numbering of [ASME B31.3](#) has been extended accordingly.

2. QUALITY ASSURANCE AND POSITIVE MATERIAL IDENTIFICATION

2.1 Initial Documentation

Before commencing fabrication of the pipework the fabricator shall prepare a quality plan and a set of design documents, both of which shall be subject to approval by the owner.

These documents should normally include materials, welding and consumable control procedures, welding and non-destructive testing procedure specifications together with supporting qualification records and an illustration of their proposed areas of application. Mechanical working, heat treatment and leak testing procedures should also be included.

Previously qualified welding procedures may be considered for use where they comply with the present document and are appropriate to the proposed scope of work. However, for critical applications, welding procedures shall require re-qualification, as directed by the engineering design.



Simplified welder instruction cards based on the qualified welding procedures should be prepared for each welding process/material combination and issued to each welder.

The quality plan shall include brief details and the sequence of all examinations that will be performed for the fabricator. The names of the individuals responsible for the implementation of all quality assurance and quality control functions shall also be included.

It shall be the responsibility of the fabricator to inspect all materials upon receipt and to ensure that the correct grade of material has been supplied and that identification, dimensions, material quality and end preparation are in accordance with the requisite standards and specifications.

Different materials shall be kept in discrete sections of the storage area and all material shall be marked in a manner that allows it to be related to the original manufacturers certification.

Procedures for the transfer of material identification marks shall be agreed with the owner prior to the commencement of fabrication.

Any material which is not readily identifiable shall be removed from the worksite and quarantined until its material grade and source can be confirmed.

All materials shall be stored above ground and kept free from dirt, grease and other contaminants.

The fabricators procedures for the storage and control of welding consumables shall comply with the requirements of BP [GS 118-4](#).

Positive identification and segregation of materials is an important issue and fabricators involved in the simultaneous fabrication of carbon steel and alloy piping should submit a Positive Material Identification (PMI) document setting out how they maintain and verify the identity of materials during fabrication. API are currently drafting RP 578 which sets out the requirements for a PMI system.

2.2 Production Documentation

At all stages of the work the fabricator shall maintain all relevant production records using a recording system approved by the owner. The records shall include:-

- (i) Material and welding consumable certificates.
- (ii) Post weld heat treatment records.



- (iii) Visual and dimensional inspection together with NDT and pressure test records.
- (iv) Isometric drawings marked up with weld numbers.
- (v) Welder and welding operator qualification test records.
- (vi) Authenticated copies of NDT operators certificates.
- (vii) Records of any agreed concessions to the fabrication standards.

On completion of the fabrication programme these records shall either be passed to the owner or stored by the fabricator, as directed by the engineering design or the fabrication contract.

2.3

Pipework Marking

All pipework shall be identified by indelible marking, free from sulphur, chloride and other halogens. When spools will be subject to post-weld heat treatment a suitable titanium oxide pigmented heat resisting paint containing less than 250 ppm of lead, zinc or copper shall be used. Vibro-etching techniques may be used for identification transfer, but adhesive tapes or hard stamping, other than that with low stress stamps, shall not be used.

All applied marking shall have a life of at least one year in covered, unheated, storage.

The marking applied shall identify the material and the fabricator and include an item number enabling the spool to be traced to the relevant isometric drawing.

Guidance on suitable colours for the identification of piping materials may be obtained by reference to [BS 5383](#).



3. FABRICATION, ASSEMBLY AND ERECTION

Supplementary to Chapter V of [ASME B31.3](#) - 1996 Edition.

The text of [ASME B31.3](#) applies, except where amended by the following text or in the engineering design.

328 WELDING

328.2 Welding Qualifications

328.2.1 Qualification Requirements

- (a) Welding procedure specifications and procedure qualification test results shall be submitted to the owner for approval before commencement of fabrication.

Each procedure qualification record (PQR) shall be certified by a recognised independent inspectorate.

The SMAW, GTAW and SAW processes are frequently employed for pipework fabrication and are considered to be acceptable welding techniques when used in accordance with this specification. The GMAW and FCAW processes are also often applied to piping fabrication. However, there are many variants of these two processes and in addition to ensuring adequate procedure qualification it is important to ensure that the particular welding technique proposed for a given application is well proven and will only be used by qualified and experienced welders.

- (d) For design temperatures below 0°C charpy V notch impact testing shall be required on carbon, carbon-manganese and 3¹/₂ % nickel piping materials, fittings and weldments as directed by [EEMUA 153](#), Appendix SA. Weld metal, fusion line and HAZ testing is required. All charpy specimens shall be cut transverse to the weld with the axis of the notch perpendicular to the surface of the test piece. Specimen and notch locations shall be as shown in Figure 1. Weld metal, fusion line and HAZ impact results shall, as a minimum, meet the requirements of the parent material.

When a welding procedure requiring impact testing is to be used in all positions, separate 2G and 5G qualifications shall be performed.

Table SA 6.1.3 of [EEMUA 153](#) gives guidance on service conditions where non-impacted materials may be used.



- (e) Backing rings are not permitted on pipework fabricated to this Specification.
- (f) P-Numbers (also F-Numbers)
 - (i) The extension of a welding procedure qualification from the material on the PQR to material of a different specification, even if it has the same P-Number, shall be subject to approval by the owner.
 - (ii) A new welding procedure qualification is required for non-impact-tested procedures if there is a change of consumable classification, and for impact-tested procedures if there is a change of consumable brand name, unless agreed otherwise by the owner.
 - (iii) A new welder performance test is required if there is a change of SMAW electrode brand name unless the brand characteristics do not differ sufficiently to affect performance. Any such change shall be subject to approval by the owner.
- (g) The welding procedure specification shall require re-qualification if any of the following changes are made:-
 - (i) A change outwith the welding parameter tolerance ranges specified in the qualified welding procedure specification.
 - (ii) Any increase of more than 1 gauge number in the electrode size from that used in the qualified welding procedure.
 - (iii) A change in the type of current, i.e. ac to dc or, in dc welding, a change in electrode polarity, except where these changes are within the electrode manufacturer's recommendations.
 - (iv) For impact tested procedures, an increase in either the maximum electrode diameter or weave width, or if the maximum interpass temperature is raised above 250°C.
- (h) Where any limitation on weldment hardness is specified in the engineering design macrographic examination and hardness measurements (HV 10) shall also form part of the welding procedure qualification.



Depending on service duty, weld metal and HAZ hardness may be subject to specific limitations. Perhaps the best known limitation is 22 Rc (248 HV 10) placed on carbon and low alloy ferritic steel weldments in sour duty in accordance with NACE, MR-0175 (see BP Group GS 136-1). A hardness limit of 200 HBN (210 HV 10) is also often placed on carbon steel weld metals in corrosive refinery environments (NACE RP-04-72). Guidance on the need for hardness limitation should be provided by the engineering design.

The hardness test may also be used to determine the effectiveness of heat treatment procedures. In the absence of specific restrictions on hardness the requirements of Table 328.2.1(h) of ASME B 31.3 may be used for guidance.

- (i) In addition to mechanical testing, welding procedure test samples shall be subjected to radiographic examination. Magnetic particle/dye penetrant and ultrasonic examination shall also be applied to the test samples if they are to be used in the evaluation of production welds. All non-destructive examination shall be completed prior to the machining of test pieces.
- (j) Ideally, welder performance tests for all positional welding should be carried out in both the 2G and 5G positions. However, subject to the agreement of the owner, the welder performance test may be undertaken in the 6G position. In that case, each welder shall also demonstrate his ability to deposit acceptable root runs in both the 2G and 5G positions. With the agreement of the owner, this may be achieved by radiography of the welders first production welds in the 2G and 5G positions.
- (k) Welders and welding operators shall be qualified by visual examination and radiography.

Subject to the provision of an authenticated CV and with the agreement of the owner, welders and welding operators may be qualified on their initial production welds.

- (l) Welder and welding operator qualification tests shall be witnessed by the inspector.

The above additions and modifications to the qualification requirements have been made on the basis of fabrication experience and will allow welding to proceed with an improved level of confidence in both procedural qualification and welder skill.

Ultrasonics may be used in lieu of radiography when material thickness restricts the suitability of radiography due to decreased sensitivity or extended exposure time.



328.2.4 Qualification Record. See 2.2.(v) of this document.

328.2.5 Test Joints

- (i) Welding procedure qualification tests for impact tested P1 steels and all higher P number materials shall be undertaken on pipe. On non-impact tested P1 materials testing shall be performed on pipe for sizes NPS 8 and below. On sizes greater than NPS 8 plate qualified welding procedures may be approved by the owner.
- (ii) All welder performance tests shall be undertaken on pipe.

328.3 Welding Materials

328.3.1 Filler Metal

In general, deposited weld metal shall be of similar composition to the parent material except that in the case of:-

- (i) Carbon steel carrying injection water or wet hydrocarbons where specific guidance shall be provided by the engineering design in order to minimise the possibility of preferential weld metal corrosion.
- (ii) Carbon steels in service at or below 0°C where a consumable containing nominally 1% nickel may be required to meet impact toughness requirements.
- (iii) $\frac{1}{2}$ Cr $\frac{1}{2}$ Mo $\frac{1}{4}$ V steels where $2\frac{1}{4}$ Cr 1 Mo consumables shall be used to minimise the risk of stress relief cracking and ensure adequate creep ductility in service.

For repairs to C $\frac{1}{2}$ Mo steels consumables of $1\frac{1}{4}$ Cr $\frac{1}{2}$ Mo composition shall be used.

The selection of austenitic stainless steel or high nickel alloy weld metal for steels containing 5% chromium can minimise the potential for hydrogen cracking and may permit some relaxation of preheating requirements. However, the use of such consumables must be compatible with service requirements, specifically approved by BP and must be qualified by procedure testing.

Final guidance on any special requirements for weld metal selection, including the selection of weld metal composition for dissimilar metal joints, should be provided by the engineering design.



328.3.2 Weld Backing Material

As stated in 328.2.1(e) backing rings shall not be used on pipework fabricated to this specification.

328.3.3 Consumable Inserts

Consumable inserts may only be used with the approval of the owner.

328.4 **Preparation for Welding**

328.4.2 End Preparation

(4) Any use of deposited weld metal to correct misalignment shall be subject to agreement by the owner.

(6) Prior to fit up the weld bevels shall be visually inspected,

Where it is considered necessary by either the fabricator's or owner's inspection or welding personnel, this visual inspection may be supplemented by either magnetic particle or dye penetrant examination.

(7) Unless approved by the owner, end bevels and holes for branches shall be prepared by machining or machine flame cutting except for holes for branches less than 25 mm nominal bore which shall be drilled. Flame cut edges shall be dressed to remove all oxide and dross.

328.4.3 Alignment

(a) Circumferential Welds

Bore misalignment in circumferential butt joints shall not exceed 1.5 mm without the approval of the owner.

(c) Branch Connection Welds

(3) Weld metal shall not be deposited to correct contour, shape or tolerances without the permission of the owner.

(e) Fabrication Tolerances

Fabrication tolerances shall comply with Figure 2 unless otherwise approved by the owner. Category M tolerances shall be used for service temperatures above 460°C and class ratings



900 and above or when otherwise specified by the engineering design.

328.5 **Welding Requirements**

328.5.1 General

- (b) All welds shall be marked with the welders/welding operators identification symbol using marker pencils or paints which are in accordance with the restrictions of Section 2.3.
- (c) Tack welds which are to become an integral part of the root weld shall be ground to a feather edge while those not intended to become part of the final weld shall be removed as welding proceeds.
- (d) Peening shall not be permitted on any pass.
- (f) Unless otherwise stated in the manufacturers installation instructions, all welding adjacent to in-line valves shall be performed with the valve in the fully opened position.

Soft seated valves (e.g. butt welded or socket welded ball valves) should not be welded in-line unless a weld procedure has been qualified to demonstrate that the soft seats are undamaged or unless the soft seat has been removed prior to welding.

- (g) Butt welds and pressure containment fillet welds in NPS 1½ and smaller pipes shall use GTAW, with the addition of filler metal, for all passes.
- (h) GTAW shall be used for the root pass of butt welds in pipes of NPS 2 and 2½ . GTAW is also the preferred technique for the root pass in all alloy steels. SMAW may be used for subsequent passes provided the electrode size does not exceed 2.5 mm for the second (hot) pass and the welders have demonstrated their ability to use SMAW on pipe of these diameters.
- (i) All GTAW equipment shall use either a high frequency starting unit or an alternative programmed touch starting unit. A current decay device should also be fitted, together with a gas lens to improve gas shielding of the weld pool.
- (j) GTAW shall only be used under enclosed shop conditions unless adequate weather protection is provided at each outdoor location where the technique is to be used.



Where gas shielded processes are being used moderate air currents can result in the loss of shielding gas leading to weld defects. Thus, sufficient screening must be used under such circumstances to keep winds and draughts away from the welding area.

- (k) Back purging shall be employed for all joints involving alloy steels and/or weld metals with a nominal Chromium content of 2¹/₄% or more. Purging shall as a minimum, be maintained for the root and second (hot) pass.
- (l) SAW and, where permitted, FCAW and GMAW shall not be used for pipes smaller than NPS 6 unless otherwise agreed by the owner.
- (m) All welds should be completed without intermediate cooling.

However, where this is impractical, intermediate cooling under an insulating blanket is permitted, but only after completion of 30% of the final weld depth. In the case of P No. 3, 4, 5, 6 & 7 materials, the heat treatment cycle detailed in 331.2.4 shall be applied.

Before welding is permitted to re-start, the weld surface shall be subject to magnetic particle examination and any preheat re-established.

Pipes shall not be moved or lifted until at least 50% of the final weld depth has been deposited.

- (n) Vertical down welding is not permitted.
- (o) Temporary attachments to the outside surface of the pipe shall not be made without the approval of the owner. Any such attachments which are permitted shall be removed by grinding, followed by magnetic particle inspection. The owner may require an ultrasonic check to establish that the remaining wall thickness is not less than the design minimum.
- (p) Whenever practicable, fillet welded joints for pressure containment should have a minimum of three weld passes, two of which should be showing for visual inspection.

The above additions and modifications to the welding requirements have been made on the basis of fabrication experience and will allow welding to proceed with an improved level of confidence in workmanship and practice.



328.5.3 Seal Welds

Joints to be seal welded shall be made up clean and without the use of tape or any compound. Welding shall be performed in accordance with a qualified procedure by a qualified welder. The welding shall not cause damage to the threaded fitting and all exposed threads shall be covered by the seal weld.

328.5.4 Welded Branch Connections

When designing angled branch connections, in addition to considering the stress concentration effects care shall be taken to ensure sufficient access for welding in the acute angle section.

When set-on integrally reinforced branch connections are used, it should be noted that the wall thickness of the connection may well be in excess of that necessary to provide the required level of reinforcement. Consequently, no reinforcement contribution is necessary from the weld metal and the deposition of a branch weld with an excessive throat thickness may lead to unacceptable distortion of the main run pipe. The engineering design should provide guidance on the sizing of branch welds when using this type of fitting and on the need for controlled weld profiles when the branch is on severe cyclic duty.

If set in integrally reinforced branch connections are used particular care should be taken in fit-up, jiggling and in developing an overall welding sequence to minimise the extent of any "sinking".

The use of integrally reinforced branch connections on thin wall pipes, sch 10 and below, should be avoided.

328.5.5 Fabricated Laps

Fabricated laps shall not be used without the agreement of the owner.

328.5.6 Welding for Severe Cyclic Conditions

The weld reinforcement shall be smooth and regular. It shall blend smoothly with the external surface of the pipe to minimise possible stress concentration effects.

The engineering design should provide any specific guidance considered necessary for weld profiles in severe cyclic duty.

328.5.7 Proximity of Welds

- (i) The toes of adjacent circumferential butt welds shall be no closer than four times the nominal thickness of the pipe with, in the case of NPS 12 and below, a minimum acceptable



separation of 50 mm. For pipe sizes greater than NPS 12 the minimum acceptable separation shall be 100 mm.

- (ii) Branch and non pressure part attachment welds shall not cross longitudinal seams or circumferential butt welds and shall be subject to the toe to toe separation distance specified for circumferential butt welds.

Where such intersections are unavoidable the main weld shall be subject to non-destructive examination prior to making the attachment weld.

- (iii) Joints involving the intersection of more than two welds shall be avoided.

330 PRE-HEATING

330.1 General

Oxy-fuel gas welding or cutting torches may only be used for pre-heating when fitted with proprietary preheating nozzles. Quenching or other means of accelerated cooling from pre-heat temperatures shall not be employed.

330.1.1 Requirements and Recommendations

If the carbon content of a P1 material is $\geq 0.25\%$, a minimum preheat temperature of 79°C shall be required irrespective of thickness or minimum tensile strength.

When establishing preheat temperatures advantage may often be taken of the lower hydrogen potential of the GTAW process, relative to the SMAW process, in setting a lower preheat temperature for welding. However, the adequacy of the selected temperature must be proven by suitable welding trials/procedure qualification testing.

330.1.3 Temperature Verification

- (b) Thermocouples may not be directly attached to pressure parts without the agreement of the owner.

330.1.4 Pre-heat Zone

The pre-heat zone shall extend 75 mm or a distance equal to four times the material thickness, which ever is the greater, beyond each edge of the weld.



330.1.5 Interpass Temperature

The maximum interpass temperature shall not exceed 250°C.

330.2 **Specific Requirements**

330.2.4 Interrupted Welding

If welding is interrupted, then the requirements of paragraph 328.5.1 (m) shall apply.

331 **HEAT TREATMENT**

331.1 **General**

331.1.1 Heat Treatment Requirements

- (e) Post weld heat treatment shall be applied where required by the engineering design.
- (f) Post weld heat treatment is required if the carbon content of a P1 material is > 0.25%.
- (f) Low melting point metals such as aluminium, lead, tin, copper, zinc, cadmium and mercury, and their alloys, shall not be permitted to contact any steel surfaces which will undergo hot forming, welding or post-weld heat treatment.

Possible sources of such contamination include solder, galvanised components, and certain types of paint.

331.1.3 Governing Thickness

The engineering design should provide any necessary clarification of paragraphs (a) and (b) in the event that specific service conditions e.g. low temperature applications or sour duty, require alternative guide-lines on governing thickness.

331.1.4 Heating and Cooling

- (i) When a furnace heat treatment is applied, the furnace temperature shall not exceed 400°C° when the pipework is loaded or removed.
- (ii) The maximum heating or cooling rate above 400°C shall not exceed 200°C per hour, and for wall thickness, 't' mm, greater than 30 mm shall not exceed 6000/t °C per hour.



The above additions are made to define heat treatment requirements more closely.

331.1.6 Temperature Verification

Where practical, thermocouples shall be attached to spool-pieces at a minimum of six equally spaced locations, adjacent to welds, prior to heat treatment.

Procedures for the attachment of thermocouples by capacitor discharge welding shall be approved by the owner and the use of this technique carefully monitored.

331.1.7 Hardness Tests

The requirement for and extent of any hardness testing shall be specified by the engineering design.

331.2 Specific Requirements

331.2.2 Exceptions to Basic Requirements

Some examples of where the engineering design may deviate from the basic requirement are:-

- (i) *The use of P1 materials in low temperature piping systems designed for use below 0°C, where the requirements of EEMUA 153, Appendix SA and paragraph 328.2.1(d) of this document should be followed.*
- (ii) *The use of P1 materials in low criticality applications at temperatures above 0°C where the limiting thickness for post weld heat treatment may be relaxed from 19 mm up to a maximum of 35 mm.*
- (iii) *Where materials are employed on sour duty or in environments liable to induce stress corrosion cracking. Reference should be made to BP Group GS 136-1.*

331.2.4 Delayed Heat Treatment

If a weldment in material of P No. 3, 4, 5, 6 or 7 is to be allowed to cool to ambient temperature prior to final post weld heat treatment, intermediate post weld heating shall be applied, as required by the following:-

On completion of welding joints of thickness in excess of 10 mm deposited by processes other than GMAW or GTAW shall be immediately raised to 300°C, for a period of 1 hour per 25 mm of thickness, with a minimum of 30 minutes. Subsequently, the joint shall be cooled slowly under dry insulation.



For all joints in materials containing in excess of 4% chromium and having a wall thickness exceeding 25 mm the temperature shall be raised, immediately after welding, to a value within the range specified for post-weld heat treatment and held at that temperature for 30 minutes. Subsequently, the joint shall be cooled slowly under dry insulation.

The above modification is made to clarify the requirements related to delayed heat treatment.

The thermal cycle associated with the intermediate post weld heating is designed to allow the dispersion of potentially dangerous hydrogen concentrations in the weld metal and HAZ. This heat treatment may also result in microstructural softening in some alloys which will often further reduce the potential for hydrogen induced cracking.

331.2.6 Local Heat Treatment

When a local heat treatment is applied, the weld shall be sufficiently heated and insulated to ensure that (for a pipe, of NPS 'D' and wall thickness 't'), the specified heat treatment temperature is achieved at the weld and that within a distance of $1.8\sqrt{Dt}$ on both sides of the weld, a temperature of not less than half of the specified heat treatment temperature is attained.

In the case of branch attachments, the temperature gradient shall be such that the length of material from each crotch heated to a temperature equalling half the heat treatment temperature shall be $1.8\sqrt{Dt}$ where 'D' and 't' are the nominal diameter and thickness of the main pipe and branch as appropriate (Figure 3).

The above modification is made to clarify the requirements for local post weld heat treatment.

332 BENDING AND FORMING

332.1 General

When designing pipe spools, particularly in P1 materials, the potential of induction bending should be considered to avoid the use of large numbers of individual elbows and minimise the extent of fabrication welding. Multiple bends of varying angles may be included in spools made from single lengths of parent pipe using this technique. The engineering design should consider the manufacturing tolerances and the need for heat treatment following pipe bending. The bend manufacturers procedures should be reviewed to confirm that adequate control is being exercised in the heating, cooling and inspection of the bends.

Typical tolerances on completed bends should be:-

- ovality at any cross section of bend should not exceed 5%



- wall thickness after bending should not be less than nominal design thickness
- angle of bend should be within 0.5° of nominal.

Following the heat treatment of cold pulled bends in low alloys steels it is recommended that a quality control check by means of hardness testing is carried out, at least in the early stages of production. The hardness testing should be carried out on one bend per heat treatment batch at four locations around the pipe circumference using a portable hardness tester of a type approved by the owner. In the absence of specific restrictions on hardness the requirements of Table 328.2.1(h) of ASME B 31.3 may be used for guidance.

332.2 **Bending**

332.2.3 Corrugated and other Bends

Fabricated mitre (segmented) bends are not generally permitted. However, subject to the agreement of the owner, limited use of mitred bends in accordance with Figure 4 may be proposed for applications permitted by BP RP 42-1.

The 'cut and shut' design shall not be used.

332.4 **Required Heat Treatment**

332.4.1 Hot Bending and Forming

The engineering design shall state any requirements for the heat treatment of P1 materials following hot bending and forming.

The fabricator shall be required to retest materials following any thermal treatment to confirm that the requirements of the engineering design are satisfied after such heat treatment.

The heat treatment of P1 materials may not be necessary if the hot forming is completed at a temperature above 900°C and the material is allowed to cool in still air.

335 **ASSEMBLY AND ERECTION**

335.1 **General**

335.1.1 Alignment

- Piping distortions. The application of heat for the correction of any minor distortion shall only be undertaken with the approval of the owner. Such heating shall be performed in accordance with an approved procedure and the maximum temperature employed shall not exceed 450°C . Spot heating techniques



shall not be employed and under no circumstances shall materials be quenched to correct alignment.

335.1.2 Bolting Procedures

Bolting procedures should be provided for each joint or group of joints to be assembled. As a minimum these procedures shall contain the following information:-

- (i) Required bolt load or stress.
- (ii) Tightening method.
- (iii) Tightening sequence.
- (iv) Elongation measurement requirements.

4. INSPECTION, EXAMINATION, AND TESTING

Supplementary to Chapter VI of [ASME B31.3](#) - 1996 Edition.

The text of [ASME B31.3](#) applies except where amended by additional requirements specified in the following text or in the engineering design.

340 **INSPECTION**

340.4 **Qualifications of the Owners Inspector**

BP will appoint a competent and experienced person having relevant practical and theoretical knowledge as the Owners Inspector.

341 **EXAMINATION**

341.3 **Examination Requirements**

341.3.1 General

- (a) For all materials, final examination shall be performed after completion of any heat treatment.

341.3.2. Acceptance Criteria

- (a) Table 341.3.2A as amplified by Table 1 of this document states the acceptance criteria for welds.



341.4 **Extent of Required Examination**

The extent of the required examination and the inspection method employed shall, for all fluid categories, depend on the criticality rating of an individual piping system. The method of determining criticality rating shall be specified by the engineering design and assigned values shall be recorded in the piping line lists.

342 **EXAMINATION PERSONNEL**

342.1 **Personnel Qualification and Certification**

Only personnel certified in accordance with PCN, CSWIP or ASNT recommended practice SNT-TC-1A, shall be allowed to undertake the examinations. In the case of ASNT, assessment of operator competence should have been undertaken by an external authority. Other equivalent qualifications may be accepted at the discretion of the owner. All personnel qualifications shall be subject to approval by the owner.

343 **EXAMINATION PROCEDURES**

Only examination procedures approved as required by paragraph 2.1 of this document shall be used.

344 **TYPES OF EXAMINATION**

344.2 **Visual Examination**

344.2.1 Definition

Visual examination shall include an examination of the internal surface of the weld where possible; full use being made of suitable optical instruments.

344.5 **Radiographic Examination**

344.5.1 Method

- (a) X-ray techniques are preferred for all shop radiography of pipework up to 25 mm wall thickness. However, where the use of X-rays is impractical, gamma ray isotopes may be used subject to the approval of the owner.

In each case the technique shall be qualified using a source side image quality indicator of the wire type to [BS 3971](#) or [DIN 54](#)



109 Part 1. The single wall, single image technique should be used when ever possible. Lead intensifying screens and fine grain high contrast film shall be used. Film density shall be 2.0 - 3.0 through the thickest portion of the weld and the radiographic sensitivity shall be as shown in Table 2 of this document.

- (b) Radiography of production welds shall use a wire type IQI with each film exposure and this shall be placed on the source side where accessible. When the complete joint circumference is radiographed in a single exposure four IQIs placed at 90 degree intervals shall be used.
- (c) Where set-on branch connections are permitted by the engineering design they should be subject to intermediate radiography with the film on the bore side of the joint when the weld depth is similar to the wall thickness and before the reinforcing fillet is applied.

344.5.3 Extent of Radiography

- (c) Spot Radiography. Spot radiography shall not be used for girth, mitre or branch welds.

344.6 Ultrasonic Examination

Where ultrasonic examination is required the approval of the owner shall be obtained for the procedures for each joint configuration and thickness. It will normally be restricted to wall thicknesses greater than 10 mm.

When fabricating pipework having a wall thickness in excess of 25 mm, consideration should be given to the examination of the root region when welding is partially complete to a depth of approximately 30% of the wall thickness. This will minimise the need for through wall repairs.

Following any necessary repairs to the root and re-examination, the weld should be completed and subjected to final examination.

344.6.3 Post Weld Heat Treated Joints

On joints subject to post weld heat treatment where examination is necessary both prior to and after heat treatment a dual approach to examination may be considered. While radiography might be the most appropriate form of examination during fabrication prior to heat treatment, ultrasonics may be more relevant in some locations subsequent to heat treatment.



Access to carry out radiography may become restricted as fabrication proceeds. In such cases it may be appropriate to perform radiography and ultrasonics prior to completing fabrication and apply ultrasonics after heat treatment to those areas which are inaccessible for radiographic inspection.

345 **TESTING**

345.4 Hydrostatic Leak Test

The fabricators hydrostatic test procedure, giving details of test fluid, minimum temperature, test pressure, pressure recording and control method and holding time, shall be reviewed by the owner.

Subsequent to hydrostatic testing, pipe spools that are to be stored prior to installation shall have the ends sealed to prevent ingress of dirt, moisture or other contaminants. Flange faces shall be coated with a suitable corrosion preventative.

Hydrotesting should be carried out after the completion of any specified heat treatment.

Current practice is to perform the hydrostatic test after the piping has been painted. Where the owner requires hydrotest prior to any painting or, alternatively, only the welds left unpainted until after the hydrotest this requirement should be clearly stated in the engineering design documentation.

Where piping spools are to be stored prior to installation, due consideration should be given to the need for the introduction of a suitable vapour phase inhibitor/biocide.

347 **WELD REPAIRS**

Prior to the commencement of fabrication the fabricator and the owner shall agree which types of welding defects are to be regarded as notifiable prior to rectification.

The fabricator shall subsequently advise the owner of the need to carry out any such repair and obtain approval prior to commencing any further work on defective welds.

Detailed records of all repairs shall be retained by the fabricator.

Repair welding shall be in accordance with approved repair procedures unless the use of the original procedure has been agreed with the owner.



As a minimum, all repair welds shall be inspected to their full extent using the techniques used for the inspection of the initial weld. The owner may require that additional inspection be applied to repairs in certain circumstances.

All weld repairs shall, where practical, be carried out prior to any specified post weld heat treatment. Where a second heat treatment is necessary the details of the procedure qualification requirements shall be agreed with the owner.

Application of a second heat treatment may have adverse effects on the properties of weld metal and some base materials. Thus it may be necessary to consider a qualification test using previously welded and heat treated material for qualification of the repair techniques. In such cases additional testing of the parent material should be carried out.



KIND OF IMPERFECTION	ACCEPTANCE CRITERIA FOR THE SPECIFIED SERVICE CONDITION
Lack of fusion	'A' for all welds.
Incomplete penetration *	'A' shall apply to all welds in severe cyclic or normal fluid service.
Internal porosity	'D' shall apply to all welds in severe cyclic or normal fluid service. 'E' shall be applicable to category D fluid service.
Slag inclusion, tungsten inclusion, or elongated indication *	'F' shall apply to all welds irrespective of service condition.
Undercutting	'H' shall apply to girth and, where approved, mitre groove welds in category D fluid service.
Concave root surface (suck back) *	Not permitted in severe cyclic or normal fluid service unless a specific limit is set by the engineering design. A maximum of 1.6 mm shall apply to welds in category D fluid service.
Reinforcement or internal protrusion	For all welds irrespective of service conditions external weld reinforcement shall be uniform, 1.6 mm to 3 mm in height and shall merge smoothly into the pipe surface. Positive root penetration shall not exceed 1.6 mm for NPS 2 and smaller, or 3 mm for larger pipe.
* When these defects are permitted the total cumulative length of lack of root penetration, slag inclusions or concave root shall not exceed 10% of the weld joint circumference.	

TABLE 1

ACCEPTANCE CRITERIA FOR WELDS

To be read in conjunction with Table 341.3.2A. of [ASME B31.3](#)



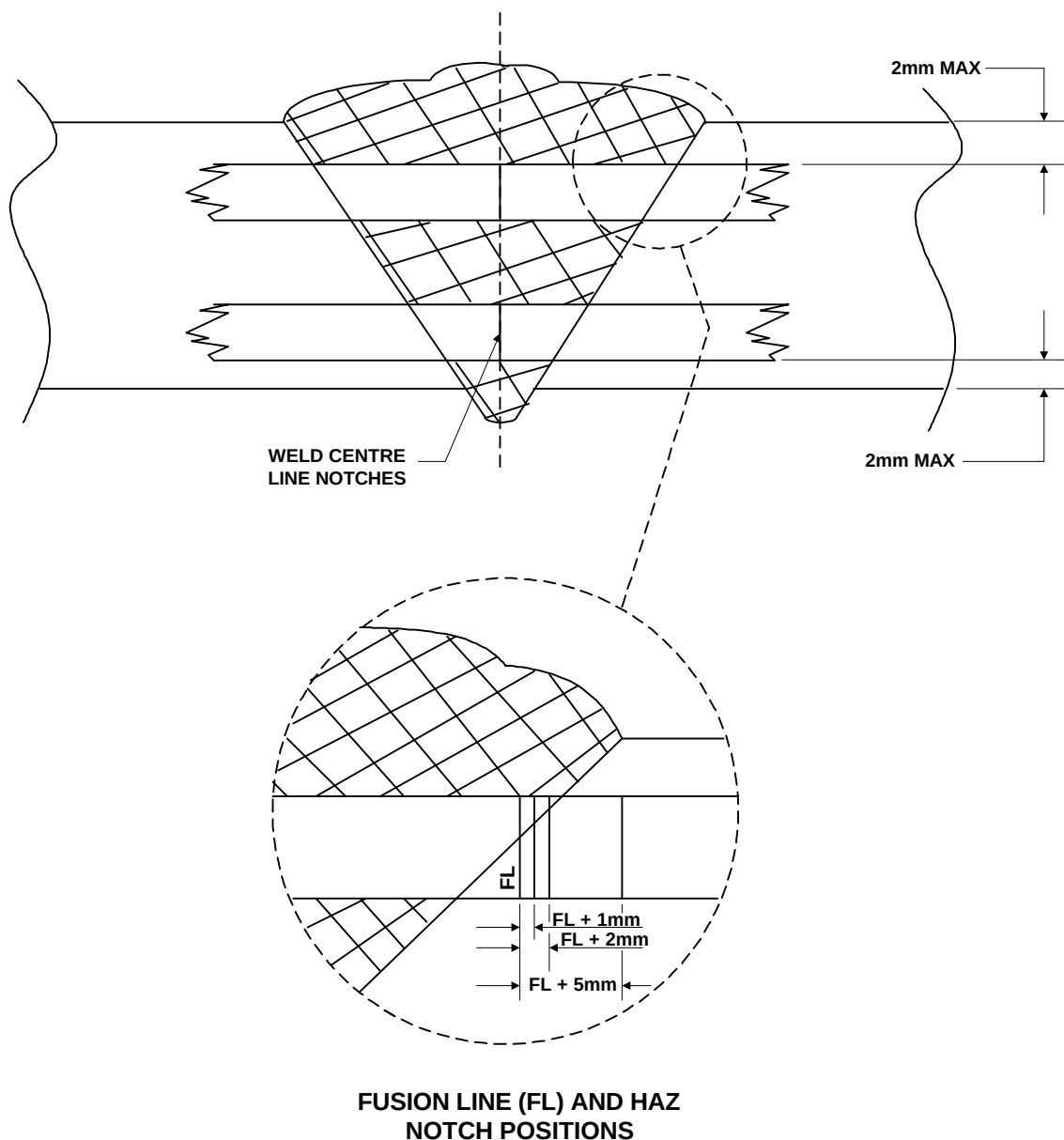
Maximum Thickness		X-Radiography	Gamma-Radiography
millimetres	inches		
3	$\frac{1}{8}$	2.4%	+
6	$\frac{1}{4}$	1.6%	2.4% *
12	$\frac{1}{2}$	1.4%	2.4%
25	1	1.2%	1.7%
40	$1\frac{1}{2}$	1.1%	1.5%

* Based on double wall/single image radiography.

+ To be agreed with the owner following the production of a test radiography.

TABLE 2
ACCEPTABLE RADIOGRAPHIC SENSITIVITY LEVELS
Using a wire type IQI to **BS 3971** or **DIN 54 109**

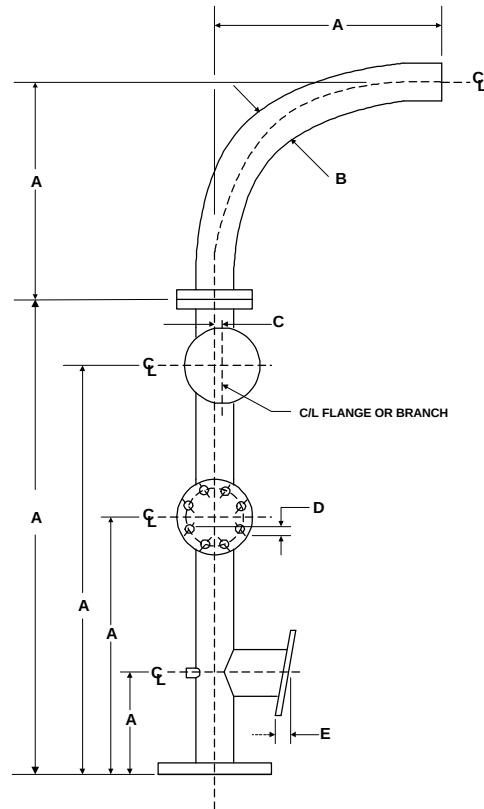




WELD METAL CENTRE LINE, FL AND FL+2mm TESTING IS MANDATORY. THE NEED FOR OTHER NOTCH LOCATIONS TO BE TESTED SHALL BE IDENTIFIED BY THE ENGINEERING DESIGN.

<25mm WALL THICKNESS	=	CHARPY SPECIMENS TO BE TAKEN FROM WELD CAP.
≥ 25mm WALL THICKNESS	=	CHARPY SPECIMENS TO BE TAKEN FROM THE ROOT AND CAP REGIONS

FIGURE 1
CHARPY NOTCH LOCATIONS

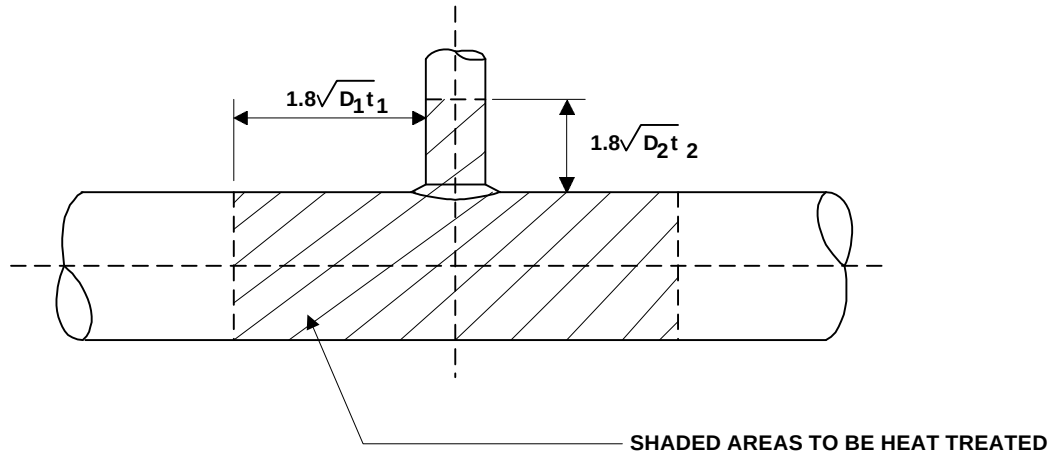


ITEM	CAT. D OR NORMAL SERVICE CONDITIONS	CAT. M. OR SEVERE CYCLIC TEMP > 460° CLASS RATING ≥ 900
A	± 3mm MAX. FROM INDICATED CENTRE TO FACE, LOCATION OF	DIMENSION FROM FACE TO FACE. ATTACHMENTS ETC.
B	8% MAX (FOR INT. PRESS) 3% MAX (FOR EXT PRESS) FLATTENING MEASURED AS DIFFERENCE BETWEEN THE MAX AND MIN O.D AT ANY CROSS SECTION	2% MAX
C	± 3mm MAX LATERAL TRANSLATION OF BRANCHES OR CONNECTIONS	± 1.5 mm MAX. LATERAL TRANSLATION OF BRANCHES OR CONNECTIONS
D	± 1.5mm MAX ROTATION OF FLANGES FROM THE INDICATED POSITION , MEASURED AS SHOWN	
E	0.75mm MAX OUT OF ALIGNMENT OF FLANGES FROM THE INDICATED POSITION. MEASURED ACROSS ANY DIAMETER	0.4mm MAX OUT OF ALIGNMENT OF FLANGES FROM THE INDICATED POSITION, MEASURED ACROSS ANY DIAMETER

FIGURE 2

DIMENSIONAL TOLERANCES FOR FABRICATED PIPEWORK





D_1 NOMINAL O.D OF MAIN PIPE

D_2 NOMINAL O.D OF BRANCH PIPE

t_1 THICKNESS OF MAIN PIPE

t_2 THICKNESS OF BRANCH PIPE

FIGURE 3

LOCAL HEAT TREATMENT FOR BRANCH CONNECTIONS

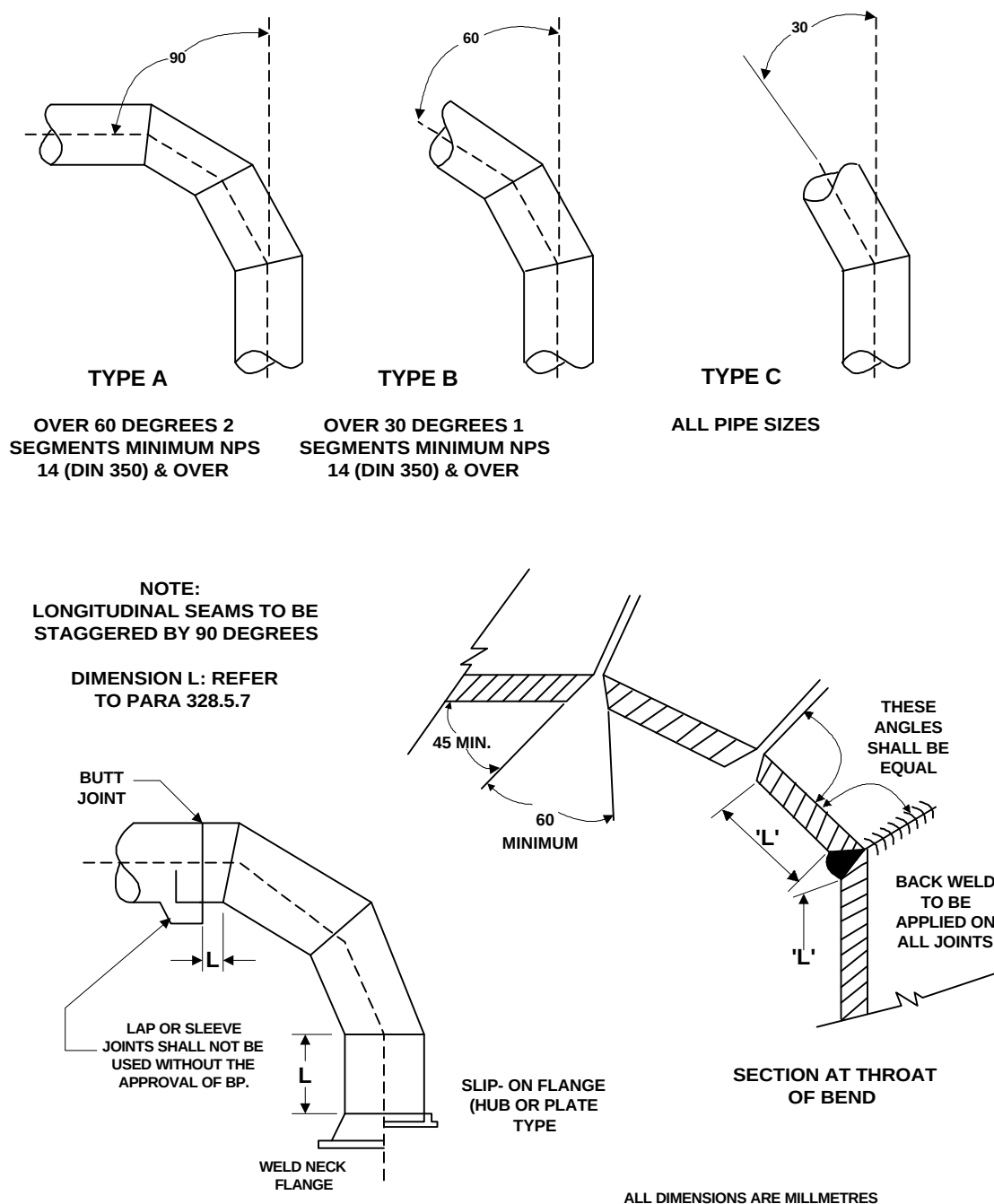


FIGURE 4
SEGMENTAL BENDS

DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

API	American Petroleum Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASNT	American Society for Non Destructive Testing
BS	British Standard
CSWIP	Certification Scheme for Welding and Inspection Personnel
DIN	Deutsches Institut für Normung
EEMUA	The Engineering Equipment and National Users Association
FCAW	Flux Cored Arc Welding
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
IQI	Image Quality Indicators
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
PCN	Personnel Certification in Non-Destruction Testing
PMI	Positive Material Identification
PQR	Procedure Qualification Record
SAW	Submerged Arc Welding
SMAW	Shielded Metal Arc Welding



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the owner's professional engineer that they meet or exceed the requirements of the referenced standards.

American

- [ASME B31.3](#) Chemical Plant and Petroleum Refinery Piping
Chapter V - Fabrication, Assembly and Erection
Chapter VI - Inspection, Examination and Testing.
- [ASNT RP SNT-TC-1A](#) American Society for Non-Destructive Testing Inc. -
Recommended Practice Non Destructive Testing.
- [API RP 578](#) (Drafting 1996) PMI for New and Existing Plant.
- [NACE RP-04-72](#) Methods and Controls to Prevent In-Service Cracking of
Carbon Steel (P1) Welds in Corrosive Petroleum Refining
Environment.
- [NACE MR 0175](#) Sulphide Stress Cracking Resistant Metallic Materials for Oil
Field Equipment.

British Standards

- [BS 3971](#) Specification for Image Quality Indicators for Industrial
Radiography (including guidance on their use)
- [BS 5383](#) Material Identification of Steel, Nickel Alloy and Titanium
Alloy Tubes by Continuous Character Marking and Colour
Coding of Steel Tubes

German

- [DIN 54 109 Pt 1](#) Non-Destructive Testing, Image Quality of Radiographs of
Metallic materials, Definitions, Image Quality Indicators,
Determination of Image Quality Index.



EEMUA and Other Documents

[EEMUA 153](#) EEMUA Supplement to [ASME B31.3](#)
1990 Edition including B31.3a, 1990 and B31.3.6, 1991
Addenda.

BP Group Documents

[BP RP 42-1](#) Piping Systems to [ASME B31.3](#)

[BP GS 118-4](#) Storage and Control of Welding Consumables

[BP GS 118-7](#) The Fabrication, Assembly, Erection and Inspection of
Austenitic and Duplex Stainless Steels, Cupro-Nickel, Nickel
base alloy, Titanium and Zirconium Pipework to [ASME B31.3](#)

[BP GS 136-1](#) Materials for Sour Service to [NACE Std MR 0175-90](#)
(replaces BP Std 153).

